Pit and Quarry

HAND BOOK

SAND
GRAVEL
STONE

1923

CEMENT
LIME
GYPSUM

443

CATALOG
7 50

Pit and Quarry

HAND BOOK

For the Sand, Gravel, Stone,
Cement, Gypsum, and
Lime Industries

1923

Price Five Dollars

Complete Service Publishing Company

CHICAGO

A WORD FROM THE PUBLISHERS

This Hand Book is presented to the pit and quarry industries in the belief that it is bringing together a mass of information which will be of inestimable reference value throughout the year.

It does not of course measure up 100 per cent to the ideals which the publishers have in mind for such a volume; but the ideals will still be kept alive for our guidance in the production of future volumes.

It is planned to make this an annual publication, with the addition of new features, and improvements in the style of presentation, as the years pass, keeping always in mind the service which our industries have a right to expect from us. This means that we shall welcome suggestions as to the contents of future issues.

The Hand Book will not stand still. The reader and the publisher working together will make each succeeding volume of greater value to these important industries.

It is impossible to do much more than make a general acknowledgment of the sources from which material has been drawn. Much use has of course been made of the publications of the Bureau of Mines and the U. S. Geological Survey. Some of this matter has been taken over almost in toto, while in other cases it has been modified and suited to our own uses.

Various authorities have also been drawn upon freely in the articles on current practice in the production of materials. The aim has been in these articles, not to give anything approaching a so-called standard practice, which would not be feasible in industries encountering such diverse conditions, but to give an unbiased survey of the various methods in use and their adaptability to different situations.

A most valuable reference feature will be found in the catalogue section beginning on page 191, and the buyers' guide following. These are designed especially to assist producers in the intelligent and easy purchase of materials, and the book should be kept in a convenient place for this purpose. It should be stated also that the manufacturers represented in the catalogue section are the ones who have made possible the publication of this Hand Book, and they are recommended to the consideration of buyers in the pit and quarry industries.

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Errata

Eckel's Cementation Index given on page 39 as

$$\frac{(\text{Percentage lime}) + (1.4 \times \text{percentage magnesia})}{(2.8 \times \text{percentage silica}) + (1.1 \times \text{percentage alumina}) + (0.7 \times \text{percentage iron oxide})}$$

should have been given as

$$\frac{(2.8 \times \text{percentage silica}) + (1.1 \times \text{percentage alumina}) + (0.7 \times \text{percentage iron oxide})}{(\text{Percentage lime}) + (1.4 \times \text{percentage magnesia})}$$

Production of Sand and Gravel

Gravels are rounded, water-worn pebbles that have their origins in almost any rock material, but chiefly in quartz which, because of the resistence it offers to the mechanical and chemical influences of wear, is not so easily reduced to the state of silt. The pebbles range in size from very fine grains to large boulders and are commonly known in their coarser occurrences as "shingle." Sands are loose, incoherent masses of quartz grains. Beach sands and wind-blown sands are smooth and rounded as a result of the abrasion to which they are subjected in being thrown together continually in the air or the surf. Most other sands are of greater or less "sharpness;" that is, they have angular grains as a result of the splitting up of rock fragments along preexisting flaws.

Sand and gravel are ordinarily found associated together in the same deposit. Sands often occur alone as such, but gravel is always mixed with an amount of sand. When the two are compacted together, the substance resulting from the union is known as a conglomerate, in which sand and other materials form a matrix that embeds the pebbles. Conglomerates are labeled with a variety of names, based upon the character of the pebbles. There are flint conglomerates, granite conglomerates, quartz conglomerates and a great number of others. Of these quartz conglomerates are the most common, just as quartz pebbles are themselves the most common.

A large part of the sands and gravels produced in the country is of glacial or fluvio-glacial origin. That is to say, these sands and gravels were reduced to their present conditions by the action of glaciers or of streams produced by glaciers. When, in their progress down over the glaciated sections of the country the monstrous ice sheets encountered loose rock materials, they carried these materials forward and finally deposited them in places far removed from those in which the materials were originally picked up. This transportation was accomplished in a number of ways and the masses of rock material, known as moraines, were left in a variety of conditions after the recession of the glaciers.

On the tops of most glaciers are great amounts of rock material derived from cliffs and peaks overhanging the ice. Deposition of this material is caused by frost action, landslips, and the forces exerted by the glaciers in its progress. The rock accumulates along the sides of the glaciers in what are known as lateral moraines. When the course of the moving ice is through deep ravines, the accumulations are very large, in many cases sufficient to obscure almost all of the ice. At the toe of the glacier is pushed forward a mass that is known as a terminal moraine. Frozen into the bottom of the glacier and grinding along over the bed of the ice sheet is another accumulation that is termed the ground moraine. Over and above the materials transported in these various ways there is carried in the body of the ice a quantity of englacial drift that was once on top but was later covered over by snowfalls which add continually to the quantity of ice in the glacier.

At the bottom of every glacier there is a sub-glacial stream, often under great pressure and discharging great quantities of water. This stream runs through a tunnel at the bottom of the glacier and in the same direction in which the glacier is tending. Great amounts of material accumulate along the beds of these sub-glacial streams, forming serpentine ridges of greater or less length. These ridges of material, mostly sand and gravel, remain in substantially the same form after the melting of the glacier. The glaciers of past ages have thus given rise to the eskers, which are today well known sources of sand and gravel for commercial purposes. The sub-glacial streams of extinct glaciers also produced the present day kames, which are hillocks or short ridges of stratified drift. The sub-glacial streams, frequently under great pressure, rose in fountains at the forward edges of the sheets and

spouted out quantities of rock material, continuing the operation with the recession of the glacier and thus giving rise to the ridged kames.

The sub-glacial streams continued to perform an important work after they had emerged from the glaciers and had come out into the open. The escaped waters picked up and spread quantities of gravel for considerable distances, creating "valley trains" in their downward courses through valleys that were not too steep. When the escape of the water from the ice did not take place in valleys, the deposits of sand and gravel were spread out and become "morainic plains" or "overwash plains." In many cases the fronts of the glaciers formed lakes by the damming of depressed areas. In such instances the sand and gravel, entering into the quiet waters, were quickly deposited around the point where the water was introduced, the fine silt and the clay floating out into the deeper water.

After the glaciers had entirely melted and the water action immediately succeeding their presence had ceased, the sand and gravel laid down as described above was frequently redistributed by other agencies that came into being as results of the conditions to which the glaciers gave rise. Rivers that had not existed before the coming of the glaciers were established. These went through the valleys in which gravel had been deposited, cut across the moraines, and transported materials to sections far removed from those in which the actual glacial action had taken place. These rivers encountered also fragments of residual materials and, carrying them downstream, wore them and broke them into still smaller fragments.

Most of the rock material handled by rivers, however, is furnished by the destruction which follows upon atmospheric erosion, by deposition of huge masses through landslips and cutting away by the rivers themselves of their own banks and beds. The chief importance of rivers from a geological point of view is that they act as carriers of materials in suspension and in solution. A tremendous amount of sand and gravel is moved through their agency.

The transporting power of water depends upon the velocity of the current. It may be interesting to some sand and gravel producers who utilize running water as a transporting agent around their plants to know that the transporting power varies directly as the sixth power of the velocity. That is to say, the doubling of the velocity of a stream of water will make it possible for that stream to carry 64 times as much material as before.

This relation between velocity and transporting power furnishes a large part of the explanation for the occurrence of sand and gravel deposits at particular places along a river. A very small increase in the velocity of a river will give it a greatly increased transporting power, while a slight decrease in velocity will bring about the deposition of a great amount of the material. Most rocks weigh from two and one-half to three times as much as water; so that, when immersed in water, they lose over one-third of their weight in air. This buoyancy of water adds greatly to the ability of a stream to sweep rock material along. The shapes of transported stones also have an important bearing on the facility with which they may be moved. Flat stones are carried farther than round stones, although round stones are rolled more easily. These are principles of water transportation as conducted in nature with which sand and gravel operators interested in river work are mainly familiar.

Oceans and lakes also produce sand and gravel, though in a different manner from rivers and glaciers. Sea gravels are the result of the erosion of rocky coasts and of the battering by the surfs and tides of the rock fragments on the beaches. High and rocky coasts suffer much more from the eroding action of the sea than do low-lying, flat, sandy coasts. Huge blocks of stone are chiseled down by the waves, after which they are rolled about and broken during storms, and to a lesser extent by the tides. They are worn into rounded boulders which are being continually reduced to smaller sizes. Only quartz seems to survive. The softer materials are ground into a fine condition and swept out by the undertows into quieter waters, where they settle. The surviving quartz fragments form the sands and pebbles on the beaches.

Larger lakes eat into their shores as do the seas, though at a much slower rate. Comparatively few lakes develop the heavy surfs that are required for rapid destruction, and the absence of tides holds the work of the waves down to narrow limits. Small lakes are merely places of accumulation and they accomplish very little actual erosion. Many lakes are, in a geological sense, which deals with long periods of time, ephemeral or temporary and are subject to being drained of their waters or of being filled up with incoming sediments. Lakes of glacial origin contain sand and gravel in the form of subaqueous overwash plains, or as deltas formed by the rapid deposition of materials in quiet waters.

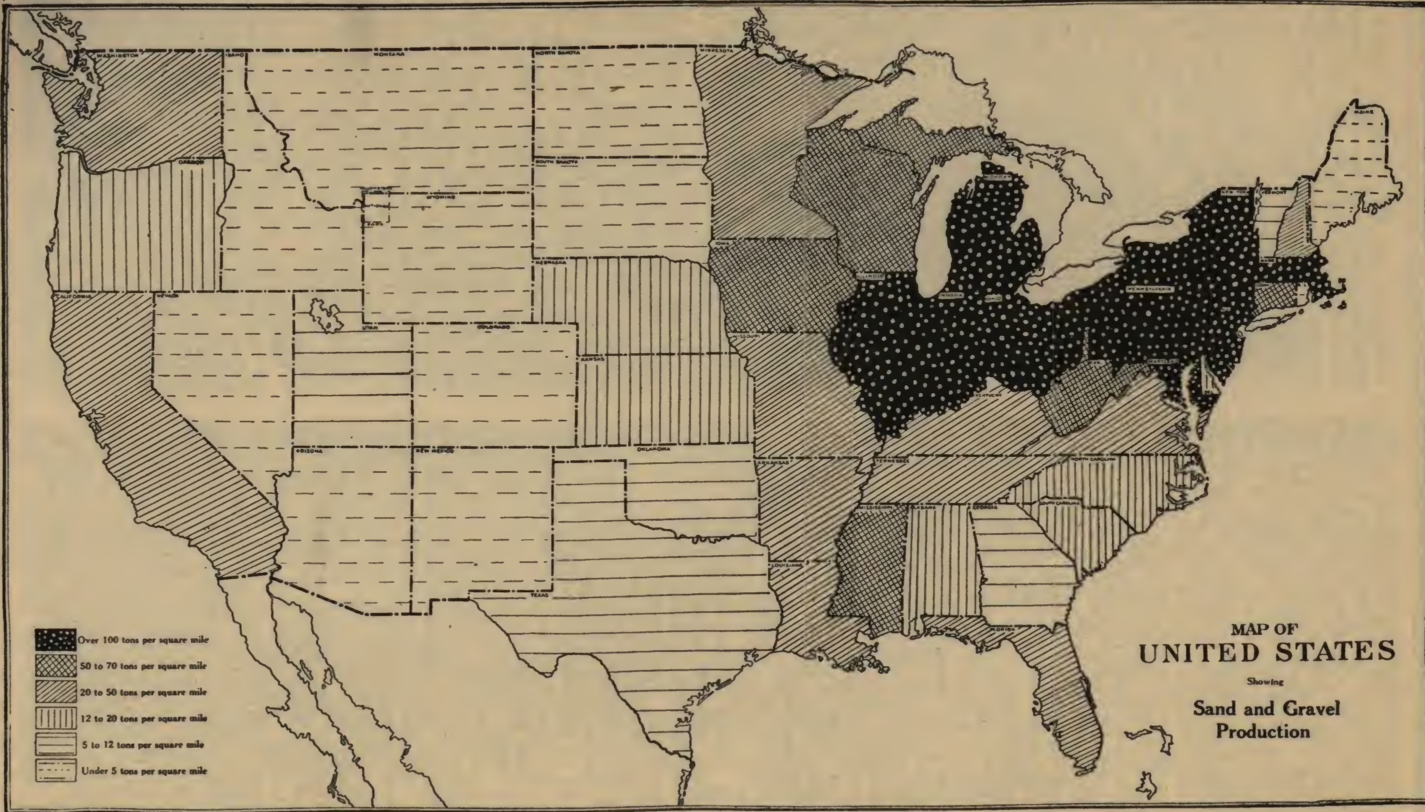
Sand and gravel are produced commercially from deposits originating in all the causes outlined above. Glacial materials are secured from eskers, kames, terminal moraines, glacial deltas, fans and overwash plains, subaqueous and otherwise. River transported materials are secured from the channels of extinct or existing streams and from floodplains and terraces along these streams. Ocean beaches furnish sand and gravel, as do the bottoms, shores and terraces of past and present lakes.

Esker deposits are very common in certain localities in glaciated sections of the country. Such deposits are found in the form of ridges 20 to 60 feet in height, 30 to 100 feet in width, and from 600 feet to a mile in length. They are usually straight, though sometimes very crooked, and have sharp crests. They are most commonly found in valleys, this because of the fact that the sub-glacial streams which created them generally followed valleys in seeking for outlets. Although the outward appearances of all eskers are more or less similar, there are great dissimilarities in the contents. In some there is hardly anything except sand, and in others nothing much but large gravel. As a rule, gravel is in abundance, and in many cases convenient proportions of both sand and gravel are obtainable. Aside from the proportions of sand and gravel in the entire esker, which may be satisfactory, there are frequently great diversities in composition from side to side, from end to end, and from top to bottom. The materials are stratified and their deposition apears to have been the work of successive seasons, the forming of strata of large or small materials depending upon the speed of the sub-glacial stream.

Kames may be considered as incomplete eskers. They are found as mounds, hummocks, or short ridges. Their sides differ from those of the eskers, in that they are steeper, this due to their former contact on at least one side with the nearly vertical ice walls. They often occur in groups. They have less uniformity of structure than the eskers and are less reliable sources of material. The sand and gravel content of any particular kame cannot be predicted with any degree of certainty. These kames usually contain gravel of all sizes, sand, clay and other materials, each occurring more or less separately from the others in pockets or lenses that are found in all possible attitudes. Kames are, like eskers, usually met with in valleys. While they are unreliable sources of material, they may, when encountered in the course of operations be made to yield up an amount of desirable sand and gravel.

There are two characteristic features of a glacial delta deposit. First, gravel occurs nearer to the delta source, the smaller gravel and sandy materials settling further away from the source; second, sand is found at comparatively shallow depths in delta-top gravel banks. The top layer in a delta deposit, the "topset" bed, is gravel and runs from four to ten feet in thickness, varying with the size of the delta. Below this comes the "foreset" bed, which is deep, sandy and inclined. Below this is the "bottomset" bed of clay, or silt, which settled thinly on the lake bottom and was covered over as the delta advanced.

Similar to the deltas in a number of ways are the glacial overwash plains, built up outside the glacier by glacial streams, which had been made sluggish by being widened out or being run into lakes. Like the delta deposits, overwash plain deposits contain thick strata of sand overlaid by rather thin deposits of gravel. In fact, they are more likely than the delta deposits to contain an overabundance of sand. Overwash plains


MAP OF
UNITED STATES
Showing
Sand and Gravel
Production
Over 100 tons per square mile
50 to 70 tons per square mile
20 to 50 tons per square mile
12 to 20 tons per square mile
5 to 12 tons per square mile
Under 5 tons per square mile

frequently overlie kame and esker deposits.

Good quantities of sand and gravel are found along sea coasts that were at one time covered by water into which a glacier had pushed a terminal moraine. In such deposits sand is more abundant on the seaward side and gravel on the side facing the land. Deposits of this kind are similar to moraines and to overwash plains; that is to say, they combine features of each. This is because they were subjected first to the action of glaciers which gave them morainic characteristics and later to the action of the sea which modified the morainic features and imparted those of overwash plains.

Flat plains into which ran swift mountain streams contain gravel deposits known as fans. The streams, in coming down mountain sides covered with loose glacial drift or broken rock, pick up a large amount of the material and carry it down to the flat plains, where the broadening out of the streams and the consequent diminution of their velocities cause deposition of the sand and gravel. Fans into which mountain torrents are still running often receive additional material when landslides, cloudbursts and other causes contribute glacial sands and gravels to the streams. As the fan widens out the materials become finer. The coarser gravels are found at the point where the swift stream first debouches on the plain or wide valley and where its velocity is checked by widening. These deposits are termed alluvial cones, as well as alluvial fans, and the former term is rather the more descriptive of the two, for the thickness of the deposit is greatest at the mouth of the ravine from which the stream flows. It has thus the general form of a section of a cone. where several streams debouch close together on a plain or wide valley a continuous fringe is formed along the base of the mountain by the coalescing of the fans. The pitch of the cone varies inversely as the size of the stream. A slope of 10 degrees to the horizontal is found in the fans of small streams.

These deposits may really be called terrestrial deltas. They are formed in much the same way as the deltas described in foregoing chapters. From them are secured large quantities of good sand and gravel, usually hard and fairly uniform in constitution.

River sand and gravel deposits may be divided into stream bed deposits, and flood plain deposits. Among the former are the sand and gravels found in the rivers themselves, among the latter the materials laid up on plains beside the rivers as a result of the action of the rivers, which at one time included these plains as parts of their beds.

In general, stream bed deposits contain materials of greater and greater fineness as the river nears its mouth. In the narrow, swift upper streams everything except the larger stones is swept along and in the process of being thus transported is considerably reduced in size. Further down the rivers, as the beds become wider and take on more easy slopes, sands and gravels are deposited. Recalling the statement in a foregoing paragraph that the transporting power of a river increases as the sixth power of the river's velocity, and diminishes in the same ratio, we can easily understand the reasons for sandy and gravelly river bottoms at points of greater width.

The processes of scour and deposition are going on continually in all rivers. There is in most cases little continuity in these actions at particular places, due to frequent changes in the volume and velocity of the rivers. At some points, however, where there are constant checks on the water velocity, there is also constant deposition, and islands and bars are built up. In such islands and bars the upstream side is sloped gently, and the downstream side is chopped off abruptly. Accretions to a deposit are made on the downstream side, the current forcing sand and gravel up the gentle slope to the steep face, over which it drops in inclined strata. Flat pebbles arrange themselves in a slanting position, so as to offer the least resistance. Upon the subsidence of the stream the strata tend toward a more nearly horizontal attitude. The result of this is a confused stratification in such deposits. The strata of varying finenesses are due, of course, to variations in the stream velocity, which variations need only be slight to effect very great differences in the carrying power of the water. The

thickness of a stratum depends upon the length of time during which a current was able to deposit, and upon the rate of deposition, which is influenced by the size and amount of the material and by water conditions.

Bars of all sizes and contents are found. Sands or gravels of quite uniform size may occur throughout such a deposit, or stratified materials of many sizes and characters may be present. All of this river material is strong, because the sands and gravels left at banks and islands represent the hard residues of stones that have been transported great distances and, in the action of transportation, freed by abrasion of any soft material with which they may originally have been associated. Another satisfactory feature in such deposits is that the supply of materials is constantly receiving new accretions. This process of replenishment makes up for the amounts of sand and gravel that have been excavated.

The flood plains along rivers are really nothing more than extensions of the stream beds over which the rivers run at high stage. When, during a flood, the usual stream bed or channels can no longer contain the volume of water present in a river, this water spreads out along the level ground at either side. The action of spreading, of course, greatly reduces the velocity of the current and deposition of various materials occurs. In the river bed proper, the velocity is unchecked and the action of deepening the channel continues to take place. In the upper parts of a river the flood plain materials are coarser, in the lower reaches they are fine or silty. The Mississippi and the Nile furnish fine examples of the way a river may, along its lower course, lay down rich deposits of river mud on flood plains.

Gravelly flood plains generally slope down the valley through which the river runs; sandy flood plains lay flat or approximately flat. The reason for this is that gravel will fall on a flood plain which has a strong downward pitch, while sand can be deposited only on level flood plains where the current velocity has been greatly reduced by the lack of a downward grade. It is noticeable that producers who are taking materials from old flood plains in wide, flat valleys, have usually much more sand than they are able to sell. At a number of Mississippi Valley plants with which the writer is well acquainted, there are veritable mountains of sand which the producer had to excavate to get the amount of gravel demanded by his market.

The mere surface indications of a flood plain, however, should not be taken as a true index of all the underlying material. Many plains that have good gravel a few feet down are covered on the top with very fine materials which were deposited by the rivers while the waters of the last flood were receding.

Rivers are thus continually building up the flood plains along their courses. At the same time that this action is going on the channel proper is being scoured and deepened by the waters within its banks which run along with unchecked velocity. This double activity of building up the flood plains and deepening the channels gives rise to another common form of sand and gravel deposit, the terrace.

Terraces are really nothing more than old flood plains. The deepening of the river channels and the building up of the plains, leave the terraces in the course of time high above the influence of the rivers and usually entirely out of the reach of modern floods. When this condition comes about the energy of the river is given over to two tasks, the further deepening of its channel, and the cutting away of its banks, the upper parts of which are the flood plains that the river itself built. Thus parts of the original flood plains are eaten away for some distance on either side of the river, leaving the parts of the plains further from the river intact. Then the river begins its work of building up a new flood plain at a lower level than the first, at the same time continuing the deepening of its channel. As time goes on and the process described is repeated, successive terraces are built up, higher and higher as they are further removed from the river. The terraces containing the oldest gravels and sands are highest, and are also furthest from the water. This may seem a reversal of the usual order in sedimentary deposits, in which the oldest material is lowest

down, and the newest material highest. Here, however, the older sands and gravels do not actually overlie the others, but are merely at higher levels.

Good examples of terraced valley formations are furnished at many places along the Illinois River. The writer has in mind a particular gravel operation near Ottawa where large amounts of material are secured from one of the terraces left when the Illinois shrunk from the dimensions of a glacier fed stream to its present size, which is relatively insignificant. Here the method of forming terraces was rather different from that described above, though employing in effect the same principles. In ages past the Illinois occupied, as has been stated, a bed much wider than its present one. When the enormous amounts of water supplied by the glaciers had been reduced and the modern stream finally established, this stream cut its gorge through the flood plain of the ancient river, leaving the outer portions of the ancient flood plain as terraces. A similar condition exists in every valley where a glacier has invaded a river from the direction of its divide.

There is another method of terrace building which results in unsymmetrical deposits. Such deposits may either be present on only one side of the river or present on both sides at different levels. These unsymmetrical terraces are formed when the stream cuts away steadily at one of its banks in its endeavor to widen a valley. This action shifts the channel to the side being cut and deepens that channel. As a result there are formed terraces which indicate former positions of the river. If this lateral movement be carried on alternately in opposite directions, there will be terraces on both sides of the stream at different levels.

The surface of a river terrace will in most cases contain a large amount of gravel, since the top of the terrace is made up of that material which is thrown down from the stream itself Under this gravel will be deposits of whatever materials were in the original valley filling through which the river had to cut in deepening its channel If the original river had been large and slow moving its bed, the valley filling, would be expected to contain fine sands, silts and clays In valleys of strong downward grade, one would look for more gravel under the upper gravelly surface. A knowledge of the geological history of a river is a great help in forming an opinion of the possible character of a terrace deposit. Very careful prospecting should be carried out in all cases.

The important characteristics of sands and gravels for most of the purposes these materials are meant to serve are durability, cleanness, and grading. The materials must be strong, must be free of organic and other impurities and must be separated into various grades of sizes. The strength of the material is determined by laboratory methods, cleanness is secured by careful washing, and grading is accomplished by thorough screening and possibly crushing.

The durability of materials is learned by applying two tests, which establish the "compressive strength" and the "percentage of wear." The application of the compressive test consist in subjecting the gravel to a crushing force and noting the intensity of the force necessary to break the pieces. The test to establish its percentage of wear is applied by putting into the laboratory counterpart of a tube mill, along with six one-pound steel balls, a quantity of washed and dried pebbles totaling 5,000 grams, and varying in size from those passing a 2-inch ring to those retained on a ½-inch screen. After the cylinder with the pebbles and balls has made 10,000 revolutions, the remaining material that is large enough to pass a 1-16-inch screen is washed, dried and weighted. The number of grams of weight lost, expressed as a decimal part of the 5,000 grams, is termed the "percentage of wear."

The other two requisites of satisfactory materials must be realized in the plant operation. After the laboratory has determined the durability of the sand and gravel, it becomes the work of the operator to excavate, wash, screen and crush the materials so that they will come up to the high standards prevailing at American plants and demanded by architects, engineers, highway commissions, contractors and others interested in the uses to which sand and gravel are put.

The methods employed at sand and gravel plants are as varied as the characters of the deposits from which the materials are secured. In general, they may be divided into two broad classes, dredging operations and bank operations. By a dredging operation is here understood one in which sand or gravel, or both these materials, are excavated from deposits under water, by a bank operation one in which the materials are secured from deposits above water. The dredging operations may be divided into lake dredging and river dredging. In each of these broad classes there are great varieties of operating methods. The choice of method in each particular case will be determined by the character of the deposit and of the material to be produced, by the amount of sand and gravel desired, by the shipping facilities and a few other factors.

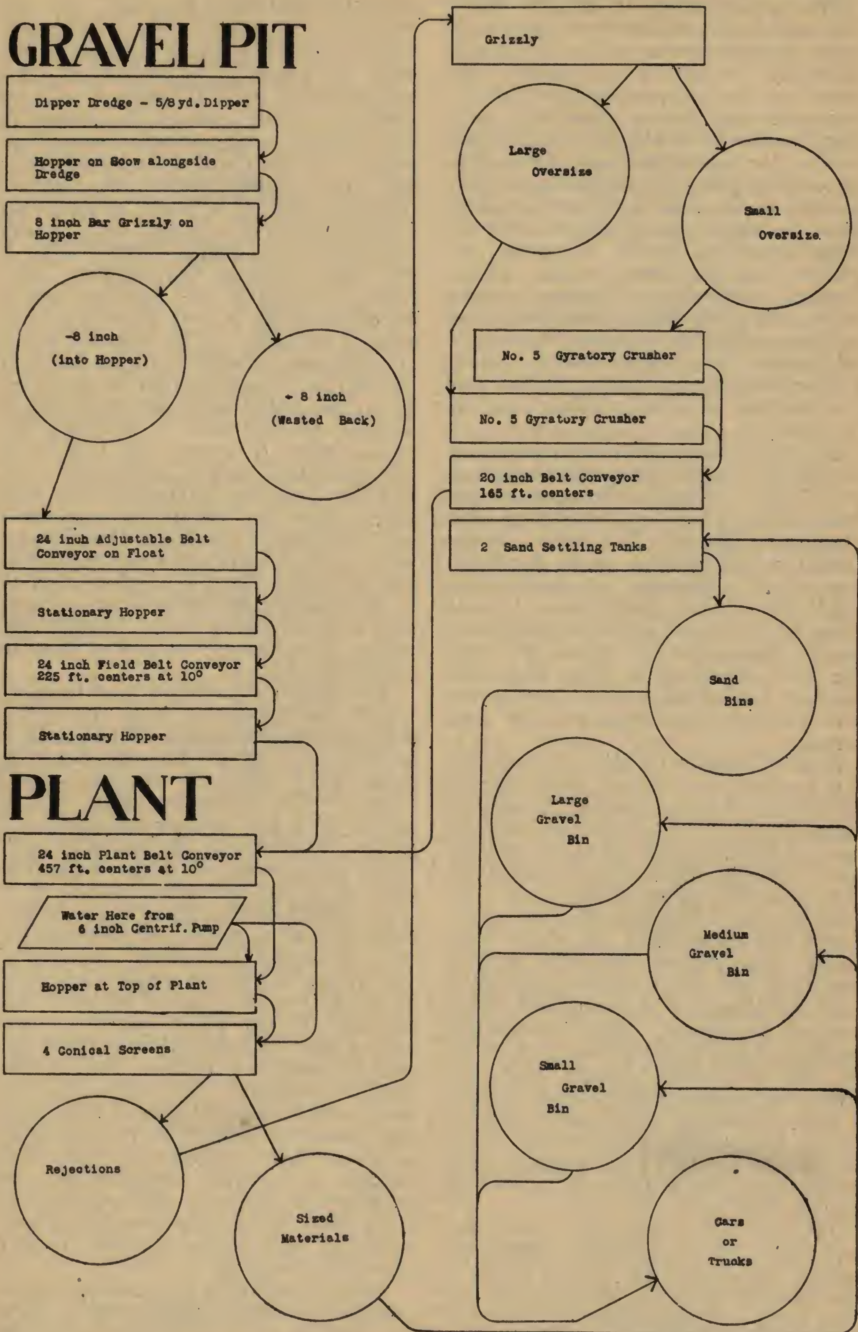
The matter of plant location is very important in this as in all other industries, particularly such industries as are included in the pit and quarry fields. The mere presence of gravel in large quantity at any particular point is not, of course, sufficient reason in itself for undertaking the excavation and preparation of the material for the market. The market itself must be assured. Determination on this point will be reached after the prospective producer has studied carefully the normal demands of such nearby points as he expects to serve, the adequacy of the existing sources of supply, and the costs of operation and transportation as compared with those of competing producers. Proximity to a large center, in which a market has been determined, carries with it certain very desirable features. There is greater opportunity of securing a good truck business direct from the plant and a fuller use of the railroad facilities is made possible.

These considerations as to plant location are all based upon the assumption that the deposit to be worked is of sufficient quality and extent to assure an uninterrupted supply of good material and a reasonable operating cost. The character of a bank deposit may be largely determined by "test pitting" the property on which the sand and gravel are thought to be. These test pits are dug at the center and corners of the property and at intervals between these points. Holes should be close enough together to furnish a reliable indication of the way the deposit lies as a whole. They should also be of sufficient depth to prove that there will be an economical working face; however, the sinking of the holes to the bottom of the deposit is to be recommended. Samples taken at various depths from the several diggings should be retained for laboratory testing purposes.

More attention is given here to the importance of a careful preliminary investigation than in articles on other pit and quarry operations, because of the fact that the great abundance of sand and gravel and the ever-increasing demands for these materials have caused many to make ill-advised ventures. The production of sand and gravel entails many hazards which should not be considered lightly. Time after time improperly tested deposits have played out, and wrongly located plants have been found incapable of producing materials for competitive markets.

In the case of bank operations the first task is that of stripping away the overburden. As stated in the article on "Crushed Stone" there are a number of ways of accomplishing this work. The steam shovel and dragline are mostly largely used, but stripping by hydraulic methods and by the use of scrapers, dragline cableways, etc., is practiced to a considerable extent. In certain favored localities where the overburden is very light as compared with the depth of the marketable materials no stripping is done and the relatively small amount of overburden is easily disposed of in the washing process.

Since the most economical stripping method, the hydraulic, is not utilized to its fullest extent, a few words on the subject may be interesting. It must be borne in mind that there are certain prime requisites for the successful employment of this method, and that without these hydraulicking cannot be considered. There must be an abundance of water, and there must be nearby low ground which can be made to serve as a spoil area and receive the water and solid stripping after it has been run off from the operation itself.



Flow of Material Through a Gravel Plant in Illinois.

The actual work of cutting away the overburden is done by a stream of water at high pressure. In one large operation visited by the writer the procedure is to pump water from a river through 12-inch pipes to a tank slightly above the highest point of the overburden and from here to send it by another pump at a pressure of 150 pounds to the nozzle. The spoil runs back to the river which, it will be remembered, is below the point at which the stripping takes place. Ditches were dug at various points for running off water and stripping. As the operation continued the water established its own drainage system by the widening of these ditches and the cutting of other ditches leading to them.

At some plants the same equipment is used for excavating and stripping, at others special facilities, separate from those used for excavation, are provided. Where the same steam shovel or dragline is used for both operations, stripping is carried on when the plant is shut down. In sections of the country where production cannot be carried on during the winter time, stripping is done while the shovel or dragline is thus freed from the work of excavating saleable materials.

A considerable number of excavating methods are in use, the selection of one method or another being determined by the conditions encountered. Still considering only bank deposits, it may be said that the power shovel is the most widely used. In such a case a working face is established and maintained, the shovel carrying development laterally against the face and dumping the excavated sand and gravel into dump cars which are run alongside. Good, economical working faces usually run from 25 to 50 feet in height, though they are frequently considerably higher. Where a face cannot be maintained because of the comparative shallowness of the deposit or the fact that water is soon encountered the dragline is often employed.

By the term dragline is included two types of excavating equipment which, while they are quite similar in the manner in which they do the actual work of excavation, are dissimilar in all other particulars. These two separate types are the boom dragline and the cableway dragline. In the operation of each of these is utilized a scraper bucket which is lowered to the point at which it is desired to take out material, pulled forward with a scraping action through the material, and elevated with a load of sand and gravel. In the case of the boom dragline the scraper bucket is lowered from the end of a boom attached to a machine on the order of a shovel or crane, and drawn forward by a line running from the machine. Material is dumped into cars or into a hopper feeding a belt conveyor running to the plant. The essential parts of a cableway dragline are an inclined track line running from a deadman up to the plant or dumping point, a scraper bucket with a carriage for transporting it along the length of the track-line, and a haulage or load line for drawing it through the material when the track line is slacked out and along the track line, loaded with sand and gravel, when the track line is taut. The use of the dragline is particularly desirable when excavation is from below water, though entirely satisfactory before water is encountered.

An excavating method that is gaining in popularity is that employing the bottomless scraper. When such a method is in effect the excavating is done by a V-shaped or crescent-shaped bucket. The large or open end is pulled by hoist against the sand and gravel, digging into the material until filled, after which it drags along the surface to the dumping point. It is then hauled back empty by a return cable for a repetition of the digging and conveying operation. Discharging of the scraper is accomplished by drawing it over a set of rails or bar grizzly. If the plant can be so designed that its top will be at this discharge point no further transportation is necessary. If this cannot be done, and it usually cannot, the sand and gravel is hauled to the plant by cars or belt conveyor. The last method is in most common use A large gravel operation in western New York gets out a great amount of material by the use of a drag scraper and belt conveyor.

Other excavating methods employed are of the dredging type; that is, they are installed to take out sand and gravel laying below a considerable

depth of water. In some of the operations included in those outlined above an amount of water is encountered but the equipment used serves also for excavating dry materials and the operations cannot be included under dredging as such.

Dredging from flooded pits is done by centrifugal dredging pumps, dipper dredges and derrick boats. These last two are nothing more than power shovels and clamshell bucket cranes on scows. The centrifugal dredging pump is usually mounted with its power equipment on a scow, but is sometimes located on shore with a pipe line running out to the suction nozzle in the pit. As the pumping method is by far the most common in dredging from pits it will be briefly described first.

For the successful conduct of a pump dredging operation it is requisite that the material be not too large to go through the pump, that it be loose enough to permit of its being excavated by the force of the suction and of the mechanical means sometimes provided in addition to the suction, that the supply of water be ample at all times, and that there be available some means for disposing of the waste water after it has been separated from the solid materials at the plant. Within certain limits pumps that will handle the larger materials can be provided. A very rough rule for determining the sizes that will clear through a given pump is contained in the statement that a pump will handle a stone whose diameter in inches is 70 per cent of the rated size of the pump in inches. Thus stones up to 7 inches in diameter may be handled through a 10-inch pump, stones 8.4 inches through a 12-inch pump, etc. Materials that are cemented may be broken up by cutters of various design arranged to operate at the suction nozzle and to provide loose material for the nozzle to take up. The coarser the material the greater the volume of water required in the pipe line. A volume of water ten times that of the solids is required in the case of most sands. As volume of water in the pipe line really means velocity of water it is interesting to note this variant of the law governing the transporting power of water in nature as expressed in an early part of this article. The dewatering of the material is accomplished with varying degrees of ease and success. Larger materials are screened out, finer materials are allowed to settle out in broad basins, or are removed in special settling tanks. In most cases the waste water, if sufficiently clean, is run back to the pit.

Where conditions in a flooded pit will not permit the economical operation of pumps a dipper may be used with success. Some deposits that contain material too large or too tightly cemented for a pump to handle may be excavated profitably by a dipper mounted on a scow and attacking the material in the same way as a power shovel, though without the advantage of working against a face.

Another method of excavating sand and gravel that should possibly have been included among those outlined above is that of sluicing. But it is really in a class by itself and is practiced to a comparatively small extent. The operation is akin to that of hydraulic stripping, but differs from this last in that it includes recovery of the materials sluiced down by the water. In such an operation the water and solids flowing away from the face are run into flumes along which they travel to the plant.

Aside from the transportation methods in effect at river and lake dredging operations, it may be said that the carrying of materials to the washing, screening and crushing plant is accomplished by railway dump cars, field conveyors, and pipe lines.

The most common means of transportation is the railway dump car. Such a car may be of the side dump, end dump or bottom dump type, and may be secured in a great variety of capacities from a few yards up to 50 yards. At a number of plants in Tidewater Virginia, the writer has recently had the opportunity to study in detail the plan of using 50 yard, bottom dump cars on standard railway trucks for transporting sand and gravel between the excavator and the plant. But large capacity dump cars are not in common use, and those carrying a few yards each are commonly employed. Loaded cars are made up into trains and hauled by steam, gasoline or electric locomotives.

The dumping of cars is done in quite a number of ways. End dump

cars which are customarily used on inclines, are made to discharge loads of sand and gravel by having the back end pulled up as the car reaches the end of the incline, directly above the receiving hopper. The method of elevating the end is ordinarily brought about by engaging of arms built out from the ends with rails beside the track, set at a sharper pitch than the track itself. The side dump cars are made to dump upon the unhooking of chains, throwing of levers, application of power, or through an air, steam, chain or cable hoist and in a number of other ways which utilize the force of gravity. The side dump cars are in most common use.

Field conveyors used instead of dump cars are sometimes of great length. The ordinary procedure when they are used is to have them run past the shovel or dragline, with an adjustable field hopper at a point where the shovel or dragline discharges. This field hopper is so designed that it can be set at any place along the length of the belt. Its function is to pass on to the belt a continuous supply of sand and gravel, at a rate determined by the plant, or the output of the excavator.

In operations where excavating is done by a centrifugal dredging pump, conveying of material to the plant is handled, of course,, through a pipe line. Frequently such pipe lines run great distances and the material has to be forced up against a high head. In some instances the force given to the material by the dredging pump is supplemented by force added by "booster pumps." The only function of the "booster" is to force the material ahead.

After the sand and gravel is delivered to the plant it goes into a receiving hopper. The purpose of this hopper is to send forward an even supply of material for the washing, screening and crushing processes. In the case of a plant receiving intermittent supplies of material from dump cars, this receiving hopper fulfills a particularly useful purpose. It is, of course, not so necessary in the plant fed by a belt conveyor, for its work is done by the field hopper which passes an even supply of material to the conveyor. Receiving hoppers are usually equipped with automatic feeders which cause an even feeding of sand and gravel from the bottom of the hopper. These feeders are of the plate or apron type. The first of these is a carriage which is driven by an eccentric, back and forth under the opening at the bottom of the hopper. The second is a continuously operating conveyor, located below the opening at the bottom of the receiving hopper, and fed through this opening with sand and gravel. In plants where a great deal of large material is handled, a grizzly separates the large stones from the smaller sand and gravel, passing the oversize 1 crushers and the smaller material to the screens. In some cases materials of all sizes are allowed to go through the crushers, but it is customary to scalp out the large sizes for crushing in the grizzly above mentioned.

The grizzly is usually a set of bars spaced about 3 inches apart and set at an angle of 45 degrees. The material is introduced at the higher end. All the small material will tall through the spaces between the bars and the large will run down the bars and then to the crusher.

In plants supplied by a pipe line with sand and gravel and water, the discharge end of the pipe line may be located so that the material will have to pass such a grizzly, thus bringing about the separation of the large materials from the sand, smaller gravel and water.

In addition to the bar grizzlies there are also a number of kinds of power grizzlies, which are designed to handle greater quantities of material than could be made to go through a stationary grizzly. Where the stationary grizzly would "blind" or clog, a power device would make possible an unhindered separation. Power grizzlies are usually of the shaking type and there is also a form of grizzly which employs a number of rolls with rings at various points along their length, touching the rings in the same positions on rolls alongside, the whole assemblage resulting in a device with a number of openings which are kept free by the turning of the rolls and their attached rings.

Scalping, the work done by the grizzlies above mentioned, is more often accomplished in modern plants by rotary screens, the rejections from which go on to the crusher. In some of these screens, arrangement is made

to take out two sizes for the crushers. Such a screen is equipped with a jacket, which passes its rejection to secondary crushers, the rejections from the inner screen going on to the primary crushers.

The work that the various scalping devices do is a very important one. As a result of the separation of sizes made in the scalping process, the crushers are relieved of a great deal of work. When all the material is allowed to go through the crushers, these machines are operating under a much heavier load, and their efficiency is directly affected.

Crushers of the jaw, gyratory, roll, disc and hammer types are used for reducing large stone to marketable sizes. The gyratory crusher is the one most used. Jaw crushers are utilized as primary breakers and rolls, hammer mills and disc crushers are employed mostly for secondary reduction.

In some plants it is customary to use the same crushers for all the work of reduction. Rejections from the screens separating the product from the crushers being sent back again to the crushers for breaking. It is customary, though, to have large stones passed to primary crushers and to have secondary crushers for reducing sizes from various points in the screening process.

Provisions made for screening around a gravel plant are governed by demands of the market. The number of sizes screened out, the sizes themselves and the proportions of the various sizes produced, depend upon market requirements. The choice of types of screens is influenced by other considerations, chiefly the experience of the operator with one or a number of types. Rotary screens, conical screens, and shaking and vibrating screens are among the various types of power driven equipment that are utilized for primary and secondary separations. Stationary and gravity screens are still in use in places, but are being displaced by the power driven devices. Gravity screens are most efficient in pumping operations. Set at angles of from 30 to 45 degrees, and consisting of wire cloth, perforated metal or screen bar surface, they can in the presence of a considerable amount of water be made to give satisfactory service. They are not so satisfactory for screening dry material or for making fine separations, for they clog too easily. They require more height than any other screens and necessitate the expenditure of more power for elevating.

The rotary and conical screens are in more common use than any other types, while the secondary screens, shaking and vibrating, are used to a large extent. Really, these last two types are forms of the gravity screen. The difference between them and the stationary gravity screen is that they utilize power. In the strict analysis, rotary and conical screens are also gravity screens, for it is gravity that carries materials from one end of the screen to the other.

Sands are taken off from rotary screens to jackets running around the screens. To a certain point sand sizes are efficiently separated by the screens. Past that point separation is best effected hydraulically. In hydraulic systems of sand separation there are provided tanks of various designs in which sand and water are introduced. They are designed variously for the washing of the material and the separation of sizes by settling.

Lake and river dredging operations are conducted along quite different lines from those in effect on land operations. River dredging is usually done by centrifugal pumps, derrick boats, dipper dredges and ladder dredges. Centrifugal pumps are most commonly used in lake operations. Dredging operations conducted in rivers by centrifugal pumps have more points of resemblance to land operations than any of the others. The materials are pumped through a pipe line resting on pontoons, to a shore plant where operations are conducted in much the same way as in a pit pumping proposition. In other lake or river pumping operations, screening, washing, sand separation, and sometimes crushing are conducted on the dredges, the finished material being passed to scows alongside. Ladder dredging operations usually provide for the production of finished product on the dredges. Some of the newer ladder dredges in operation around more or less important centers are quite pretentious crafts that con-

tain complete sand and gravel washing plants and quarters for working forces.

Dredge boats and dipper dredges usually operate on a different plan. The material is excavated from the river bottom and brought into barges in the condition in which it is recovered. These barges are towed to the shore plant where the material is taken off by clam shell buckets and passed to the finishing plant.

Deposits of sand and gravel in rivers are also reached by dragline cableways. The deadman is located well out into the stream, and the bucket, in traveling between this deadman and the plant, makes a cut which is continually being supplied with new material by the action of the river. Very satisfactory results are reported from a number of quarters where this plan is in effect.

Each of the methods touched upon above would furnish material for a long treatise and cannot, consequently, be treated at great length here. Our purpose in this article has been merely to touch on some of the main features of sand and gravel occurrences and production. Articles to be published later will touch upon all these points in detail.

Methods of Producing Crushed Stone

Crushed stone, used for many purposes, is secured in a variety of ways from a number of the rocks found in nature. In this article it is proposed to touch upon the production of such material only as is used for concrete aggregate, fluxing, ballast, agricultural stone and a few other purposes. The stones suitable for these purposes include limestone, silicious limestone, ferruginous limestone, dolomite, granite, marble, quartzite, basalt, gneiss, diabase, hornblende schist, amphibolite, volcanic breccia; and sandstones, calcareous or otherwise. Some of these terms are rather uncommon to the average quarryman who thinks of crushed stones, principally in terms of limestones, granites, trap rocks, and possibly a few other varieties. The trap rocks here mentioned are a group of dark, fine-grained, igneous rocks that are principally accounted for above under the heads of basalt and diabase.

Limestone is the material most commonly quarried for preparation and sale as crushed stone. It is found in every state of the Union, though sometimes in quantities too small to be seriously considered as forming a commercial supply. Limestone is the general term used for sedimentary rocks composed essentially of calcium carbonate. An amount of space is given to the subject of limestone in the article on lime in another part of this book. Limestones that have associated with them a considerable amount of silica are known as silicious limestones, those which contain iron in appreciable quantities are termed ferruginous. When a stone that is principally calcium carbonate is associated with magnesium carbonate that constitutes as high as 40 per cent of the total, the stone is called a dolomite. It is harder than limestone and exhibits a number of different chemical characteristics. When the percentage of magnesium runs very high, the stone is a magnesite, a very hard substance that occurs in comparatively small quantities. It may be said in connection with limestones that a calcium carbonate is always associated with a certain amount of magnesium carbonate.

Granite is a granular igneous rock usually composed of quartz and mica. Commercially almost all compact igneous rocks are called granites as distinguished from other stones, mainly of sedimentary origin, such as limestones, marbles, slates and sandstones. Syenite, quartz syenite, and granites are included usually in the same group as the true granites.

The terms sedimentary and igneous have just been used in describing limestones and granites. A sedimentary rock is one formed by the accumulation of sediment in water or air, the process occurring geological ages ago. The sediments may have consisted of rock fragments or of the remains of extinct animal and vegetable life, of the product of chemical action or evaporation, or of a combination of all these causes. It is characteristic of these stones that they are, if undisturbed by natural processes, in flat beds or strata. The igneous stones were formed by solidification from a molten state in which they existed at some point in geological time. A great many of them exist as a result of volcanic action.

Marbles are metamorphosed and recrystallized limestones. In other words they are limestones whose texture and composition have been changed (metamorphosis) by induration (hardening) as a result of the action of exterior agencies, such as rise in temperature, produced by inclosed pressures or other causes, and later forming into a stone of distinctive crystalline character.

Quartzite is another metamorphosed rock, a quartz or stone high in silica formed by the deposition of secondary silica between the sand grains of the original rock, the silica cementing the grains together into a hard stone.

Basalts are understood in the broader sense of the word to include all the dark basic rocks of volcanic origin. Diabase, too, is a dark igneous rock occurring usually in intrusive sheets or dikes and composed of feldspar and augite with small quantities

of magnetite and apatitie. It has lath-shaped crystals lying in all directions among dark irregular grains, giving rise to its diabasic texture.

Gneiss occurs commonly as a layered crystalline rock with a more or less well developed cleavage. It is found as a mica gneiss consisting of mica, quartz and feldspar and as a hornblende gneiss consisting of hornblende, quartz and feldspar.

Hornblende is a variety of the mineral amphibole which will be described later. It contains calcium and magnesium with silica, usually also some iron and manganese. Hornblende schist is a metamorphic rock consisting wholly or chiefly of hornblende, that is schistose, or can be readily split or cleaved because of its foliated or parallel structure.

Amphibolite is a metamorphic rock, sometimes used to mean hornblende schist, a normal metasilicate of calcium and magnesium. It occurs associated with iron, manganese, sodium, and potassium.

Volcanic breccia is a term that applies to rocks with reference to their physical rather than to their chemical constitution. They are volcanic rocks that occur in fragmental form with angular components.

Deposits of stone vary considerably as to the manner in which the stone is disposed, as well as in the chemical composition of the material. It occurs in many places as massive formations; in many other places in thin strata. Stratification is usually horizontal or approximately so. Frequently, however, ledges of stone are found that are tilted at all angles between the horizontal and the vertical. Deposits may, in some cases, outcrop or at least be found very close to the surface and may in other cases underlie the surface at a considerable depth. The material overlying the stone, called the overburden, is of many kinds and is usually encountered supporting vegetation.

Most stone is secured by quarrying —that is to say, stone is excavated from open face workings. Occasionally, though, it is secured by mining or tunneling and in some cases by what is termed "glory hole" mining. The method to be adopted in excavating the material is contingent upon a variety of circumstances—the lay of the strata or seams, the depth and nature of the overburden and the advantageous location of the mill with respect to the workings.

The ideal quarry, so far at least as drainage and the saving of power through gravity conveying is concerned, is the hillside quarry. In an operation of this kind the quarry is located a considerable distance above the mill on a hill or mountainside. Stone is excavated at the top and is conveyed to the plant either in the quarry cars into which it is loaded at the face, or in special skips, the use of one or the other being determined principally by the pitch of the incline from the quarry to the mill. The balanced car method is principally in vogue in this case, the loaded car of material going down the trackway on the incline, pulling up an empty car before reloading. The whole operation is controlled by a friction hoist at the top. Details of this method of conveying will be described later in this article, when general consideration is given to all methods of conveying limestone and other materials.

In other places the quarry operation is at grade, the floor of the quarry being at the level of discharge into a preliminary crusher. In other cases, and these are by far the most common, the quarry operation is below the level of the plant and stone must be hauled up. Decision to employ one method or another is of course almost entirely dependent upon the natural features of the deposit.

As the open face quarry is most common it will be described first and the features common to all quarries whether above, at, or below the level of the mill will be discussed.

The first operation in the process of excavating stone is that of stripping, or the removal of overburden, by which term is meant any material overlying the stone, which may or may not be used later. In many quarrying operations this matter of stripping adds considerably to the cost. The depth of the overburden to be removed, of course, has a direct bearing upon the extent of the operation, but it is not the only determining factor. The writer has in mind a limestone quarry in Chicago where the matter of stripping no longer counts, and never did count to any

great extent. This quarry is some 360 feet deep, the deepest open face limestone operation that we know of. The quarry is about a city block square in area. It was opened 65 years ago and has been worked steadily downward since the company reached its property line and could no longer continue lateral development. There was not an excessive overburden in the first place, but even if there were it would have been worth while removing because of the great depth of workable stone that lay below it.

In other places, where the stone ledges are thinner, the cost of stripping is greater because of the necessity of heavier and more frequent removals of material overlying the stone.

Quite a variety of methods are employed for removing overburden. Among these are the use of scrapers, pulled by horses or mules, the use of shovels and derrick box, shovels and dump cars, clamshell bucket and traveling crane, steam shovels and overhead cableway. The use of dragline scrapers and hydraulicking equipment are also common. Hand shovel operations are resorted to only where a small amount of overburden distributed over a small extent of ground is to be moved. The work is done in most places by scrapers, shovels, cableways and bottomless scrapers. If the stripped material is to be conveyed to a considerable distance, wagons or dump cars are employed.

Hydraulic stripping, while still not in very general use, has been adopted at quite a number of places where conditions are suitable. These conditions obtain at many other quarries and the work of stripping could be done very efficiently by hydraulic methods.

A wet quarry offers a good opportunity to do stripping hydraulically in connection with the pumping out of the drain water. When the stone must be washed at the crushing or screening plant it is also economical for the pumps to do the double duty of washing and stripping. In cases where water can be brought down from springs on a mountainside, a great head can be obtained without the use of pumps.

The question of available ground to place the spoil is an important one where a hydraulic stripping operation is contemplated. This spoil is, of course, largely liquid and must be retained by some means so that it will not be spread over adjoining property. Retaining walls are usually made of logs, brush or boulders. Trenches or troughs are provided to carry away the water, leaving on the other side of the spoil bank the solid material stripped away at the quarry.

Abandoned workings form very good dumps for the solid stripping and in many places an amount of good land, suitable for agricultural purposes, is reclaimed through the dumping of clay and soil in these old quarries.

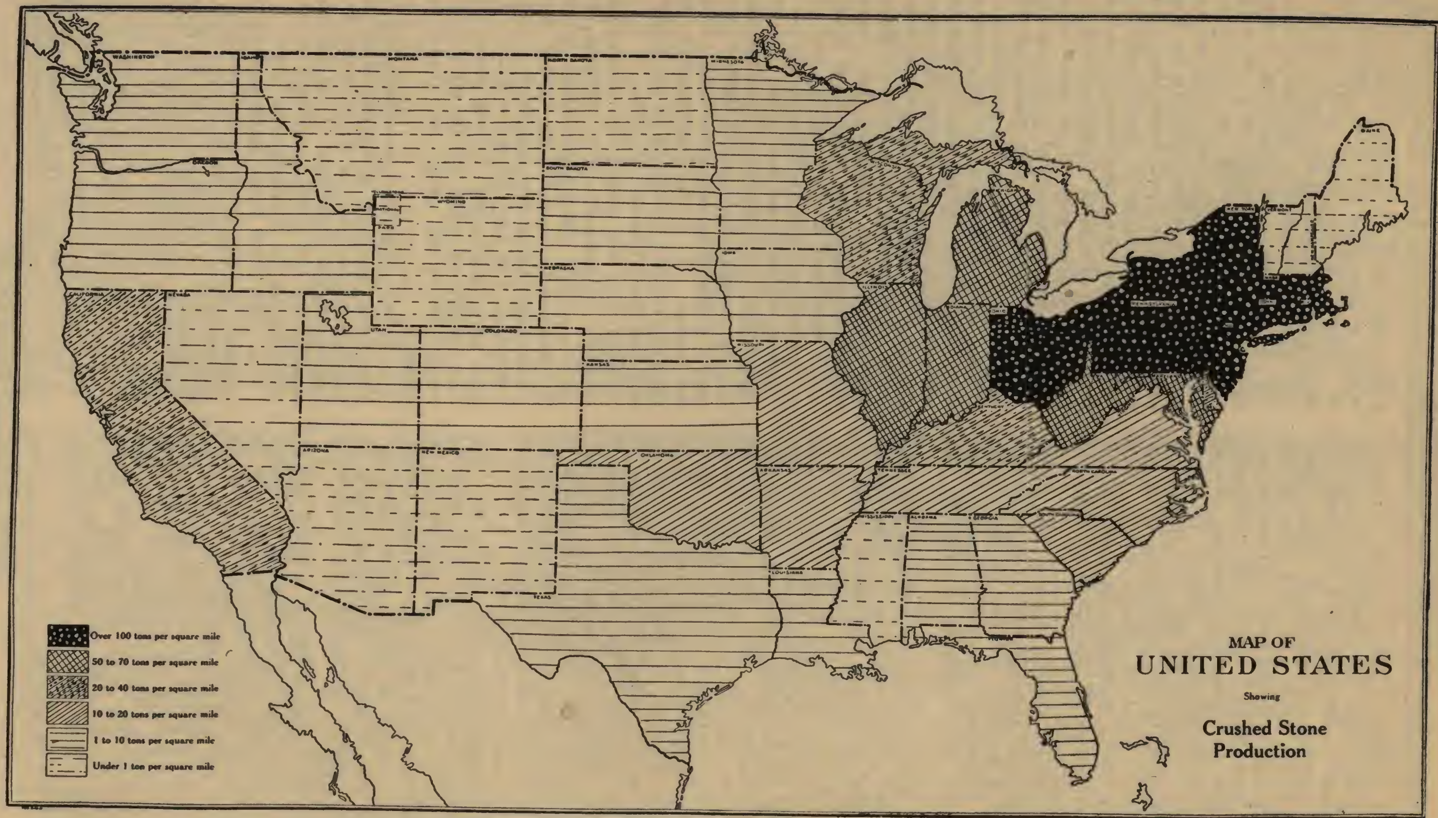
The derrick box is used to remove strippings from ledges inaccessible to other equipment. It serves this purpose well, but its use is not economical. The cleaning out of clay pockets, a work akin to stripping, has been done successfully by a dragline excavator operated from a derrick arm.

In certain cases an amount of overburden, while it adds to the cost of production, constitutes a real advantage by reason of the fact that it prevents weathering of the stone. This advantage is more appreciated in quarries where limestone is excavated for the manufacture of lime.

Most of the extensive stripping around quarries is done during the winter. This does away with interferences with production during the producing season and gives the superintendent but one job at a time. It also permits the use during otherwise idle months of some of the equipment employed in the work of producing stone.

Before taking up a consideration of the other steps in the production of crushed stone we will touch upon the more general features of quarrying, classifying the various open face operations as to working methods.

An open face stone quarry may be worked "single face" or in "benches." In the first of these methods the stone is secured by blasting it away from the face by explosives that are effective to the level of the quarry floor. In the second method this same work is accomplished in a number of steps, a 90 foot face, for example, being worked in three 30 foot "benches," or levels, the highest of these advanced


MAP OF
UNITED STATES
Showing
Crushed Stone
Production
Over 100 tons per square mile
50 to 70 tons per square mile
20 to 40 tons per square mile
10 to 20 tons per square mile
1 to 10 tons per square mile
Under 1 ton per square mile
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
NEVADA
CALIFORNIA
UTAH
COLORADO
KANSAS
MISSOURI
ILLINOIS
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TENNESSEE
NORTH CAROLINA
MISSISSIPPI
ALABAMA
GEORGIA
LOUISIANA
TEXAS
FLORIDA
KENTUCKY
MAINE

the farthest laterally. Decision to employ one or another of these methods will be founded on a study of the attitude of the rock beds and the character of the bedding, and also of the topography of the immediate surroundings. Single face quarrying is practiced where the deposit being worked is massive in formation, or, where stratified, does not contain too much undesirable material between the strata of good stone. Quarrying in benches is done where beds of undesirable material are included in the rock series and is successful only when the bedding is horizontal or nearly so. It permits the extraction of good stone even from a badly mixed series.

Another method of quarrying that may be called an "open face" operation, but is not entirely so, is "gloryholing." This method is not much in vogue with crushed stone producers. It is practiced to a considerable extent in iron mines and in a number of metallic operations. The advantage of this method in some cases is readily apparent. This system can be used to good advantage in working a ledge inclined at about 55° or 60° to the horizontal, the top part extending above the plant. A haulageway is run into the ledge running through the strata that occur between the plant and the ledge to be worked. The inner end of this haulageway meets a rise running up vertically to the open through the stratum of good stone, and ending at the top about in the center of the exposure of tilted rock. The operating method calls for the excavating of stone in the regular way—that is, by blasting, with the idea, however, of carrying on development downward instead of laterally. The blasted stone is dropped down the rise to the end of the haulageway, to which come mine cars to be filled from a loading pocket at the bottom of the rise. These cars are then hauled along an even grade to the plant. Operations can be carried on very economically when conditions are favorable. Preparatory work, however, is very costly.

In a few places in this country stone intended for crushing is secured by underground mining methods proper. The operating method may be of the "room and pillar" or stoping type. These methods prevail more where stone is to be used for purposes other than those to which the crushed stone considered in this article are usually applied. For example, very fine grades of limestone intended for burning into lime are secured by these methods, as is also stone intended for use in the manufacture of Portland cement. Forming parts of higher priced products as they do, their production may be carried forward at greater cost.

In an open face quarry the first work, after the stone has been exposed by stripping off the overburden, is to drill loading holes for explosives and to blast the material. This blasting operation is intimately connected with that of drilling the blast holes, so the two will be considered together.

Aside from the hand tools employed occasionally, the types of drilling apparatus used around stone quarries are of three kinds; well drills, tripod drills and air hammers. Well drills are used entirely in drilling vertical holes and are of chief advantage where high faces must be blasted down. They commonly drill a hole 5⅝ inches in diameter, but holes up to 12 inches may be made by this method. The effectiveness of the big blast holes made by them lies in the fact that they hold a large quantity of explosive which can be distributed to the best advantage. They are operated by electric, gasoline or steam power. Tripod drills are, as the name indicates, drills mounted on tripods. They are operated by steam or compressed air and drill holes 1 to 3 inches in diameter. They may be used on the tripods for drilling vertical holes or mounted on a crossbar, singly or in pairs, for drilling horizontal holes. Air hammers are more portable tools. They are used around quarries chiefly for the secondary blasting of large stone, shot down in the big blasts, that are too bulky to handle and must be reduced. They are operated by compressed air. They drill holes of smaller diameter up to 10 feet in depth.

In preparing a blast in a quarry with a fairly high face, vertical drill holes are driven down at a distance back from the face and at distances from each other that are determined by the nature of the stone, the extent of the shattering action required and

the character of the explosive to be used. The diameter of the hole, its depth and the employment or non-employment of charges shot in holes driven in other directions are also governed by these considerations. If the formation is fairly regular and no other factors complicate the calculation, the holes are driven to a point slightly below the quarry floor. The purpose in loading explosives at depths below floor level is to shoot away all the stone clean to the floor level. In other cases the vertical holes are used in conjunction with horizontal holes driven into the face at about floor level and back almost as far as the distance of the vertical holes from the face. The combined action of explosives properly loaded and detonated according to this system produces very good results in many cases. The plan is used in blasting high faces.

Another method of blasting high faces is by the use of tunnels 3 to 4 feet in height and 40 to 50 feet back horizontally into the face. Off these tunnels are driven crosscuts with recesses for explosives left at distances determined by the hardness and weight of the rock and the degree of fragmentation that is required. This method is called "tunneling" or "gopher-holing."

"Snake-holing" is practiced on quarry faces up to about 50 feet in height where the formation is hard, massive and irrgeular with no particular lines of stratification or cleavage and where vertical holes cannot be drilled with economy or speed because of the fact that the strata are on edge. Holes are drilled almost horizontally at a point about 2 feet above the quarry floor and with just enough drop to bring up the end of the hole at floor level. Snakeholes are not driven in over 25 to 30 feet and are usually spaced about 8 or 10 feet apart. A combination of snakeholing and well drilling is described in the second paragraph before this.

Often, for the sake of accommodating sufficient explosive to accomplish a given task, the ends of the various blast holes are "sprung" or worked out to form pockets for the accommodation of explosive. Light charges of dynamite are exploded at the places to be sprung, the explosion resulting in the widening and deepening of the hole and the consequent formation of a roomy cavity to be filled with explosive.

After the holes are drilled comes the task of loading them. This work is done in the case of the vertical well drill holes by dropping the dynamite into the holes or by lowering it with special tongs. Sometimes spaces are left between areas in the holes in which dynamite has been loaded and these spaces are filled with "tamping" which term is used also to describe the act of pounding the dynamite and "stemming" (a better word than tamping in this sense) so as to close up the hole tightly and prevent the loss of any of the force of the dynamite. Moist sand, clay or soil is used for "stemming." Improper tamping and stemming result in the waste of a large part of the explosive force.

The results most desired in a good blast are the even shattering of the stone to a degree of fragmentation determined upon as most economical for the loading and crushing facilities available. The stone should be dropped as evenly as possible at the foot of the face, not spread over too much ground. The quarry face should be left in good condition and the quarry floor maintained.

The firing of the holes is accomplished in one of three ways: by setting off blasting caps by fuses, by electrically exploding an electric blasting cap, or by the use of cordeau, an explosive compound encased in narrow lead tubing which, upon being itself detonated, explodes along its length at the rate of about 17,500 feet per second. All three of these methods employ the same principle, the creation of an explosion in a body outside the dynamite itself and the detonation of the dynamite through the shock produced by this explosion. It is customary to fix the blasting cap or electric blasting cap to the bottom package of dynamite in a load, the wires or fuse running alongside the rest of the charge. Cordeau is merely wound around or laced into the bottom package and allowed to reel out until the bottom is reached. Fuses are lit by fire, electric shots are set off by detonators or portable dynamos operated by a downward push, cordeau is set off by firing in the usual way, a blasting cap crimped to its up-

per end, the cordeau then exploding almost at the same time along its entire length. Sometimes two detonating machines are used in firing the same set of holes to insure good results.

The question of blasting is a big one with quarrymen. Considerable reliable literature of recent date is available and all the powder companies help the producer with instruction sheets, manuals, the visits of expert powder men, and in various other ways.

After the stone has been shot down from the face, the work of loading begins. Coincident with this task is carried on that of breaking by secondary blasting any stones that have not been reduced sufficiently by the primary blasting and are too large for convenient handling. One way of doing this is by the use of "mudcaps" or "dobie" shots, which are prepared by placing small quantities of dynamite on the stones to be blasted and covering these with mud or clay to hold them to the stones. A large part of the force of a "dobie" shot is dissipated into the air but sufficient of it is utilized to break the stone. This method is very wasteful as compared with "block-holing," which calls for drilling a hole in the stone with an air hammer and exploding dynamite in the opening thus made.

Blasted stone is loaded at the face into quarry cars by steam shovel or by hand. The choice of one or the other method depends upon a variety of circumstances. The height of the quarry face has an important bearing on the decision to employ one method or the other. Shovels are usually to be preferred at a quarry face less than 40 feet in height. At such a face the stone can be blasted down so as to fall on the floor close to the face. This makes for efficiency of operation with a shovel, large machines cleaning up an entire shot in one passage. When the blasting is done from a higher face, the shovel must pass the front of the blast a number of times, in order to clean up the loose rock completely. This results in irregularities of production, the stone not occurring in even condition at the time various trips of the shovel are made. Sometimes when blasting is done against a shot that has been already made, in order to keep the rock loose, this gives the shovel plenty of material to work with and makes the work itself easier. On a high face, too, the stone usually comes out shattered to a less degree, giving the shovel a difficult work of handling very large pieces. The blast can, of course, be arranged to secure final fragmentation, but possibly not with economy.

Railway type shovels, mounted on double railway tracks, are usually employed. They run on tracks laid down in the direction it is intended that the shovel shall travel. Smaller shovels on traction wheels are also used where quarry floors will permit their use and where quarry conformations make the railway type shovels not so desirable. Caterpillar tread shovels are also used to an extent.

Hand loading is done with economy in many cases. Where labor is cheap or where a very deep quarry of small area is worked, hand loading is preferred, although it is a very laborious operation. Hand loading practice, of course, makes an employer more dependent upon local labor conditions for his production than he would be if he were loading with a shovel. On the other hand, when a shovel is used, it is a more limiting factor in production. When shovels break down, plants whose operations are organized along the lines of mechanical loading have to shut down. In general, shovel loading is much to be preferred, but it is not always possible to use shovels with greater economy than hand loading methods.

The practice of hiring loaders on the contract basis is quite common. When this method is in vogue, cars of stone are checked off as they come to a certain point, and the man or men doing the loading are given credit. In some cases these contract workers furnish their own tools, but usually the operator does this.

The loading, whether by hand or shovel methods, is usually into various types of dump cars hauled between the working face and the plant by steam, gasoline or electric locomotives, or by mules. In some quarries, the loaded cars are pushed to the plant by laborers. This is done only in cases where labor is cheap and where quarry development can be carried

forward to provide a floor with a slight incline from the face down to the plant. In a number of Southern quarries visited by the writer where this method of transportation is in effect it seems to be working out satisfactorily enough, the men pushing the loaded cars without difficulty along the down grade to the plant and shoving the empty cars back. This plan cannot, of course, be used where the working faces are located at any distance from the plant.

An important factor in the efficient operation of a quarry transportation system is the track arrangement. In hand loading operations the general plan is to run tracks up to the places where the men are working, the system calling for a fanning out of the trackage, a radiation of a number of track systems from the main haulage track to the plant. In shovel loading the plan is to have the haulage track run past the shovels, the trains of empty cars coming alongside, taking on their loads and continuing in the same direction, at least for a short distance. In quarries where the plan of development will permit the haulage track is laid out roughly in the form of a circle, the outer edge running close to the shovel or shovels. A continuous operation of the trains is thus made possible.

Dump cars are of various kinds. In hand loading operations the cars are low so as to permit laborers to fill them with stone without undue effort. In shovel operations, they are high. It is more economical to load a high car than a low one because the dipper of the shovel, when it completes its working stroke and comes up full of stone, is raised to a good height. The saving of an appreciable amount of time in a day is accomplished by having the dipper discharge in this elevated position without putting the shovel operator to the necessity of lowering the dipper down to a low car. A good deal of stone is also spilled in loading low cars with shovels. As would be expected, larger and heavier cars are used in power shovel operations. They are larger because the providing of a larger area in which to dump makes the spotting over the dump car of the loaded dipper an easier matter. They are built more heavily than the cars used in hand loading operations because they have naturally to withstand more severe treatment.

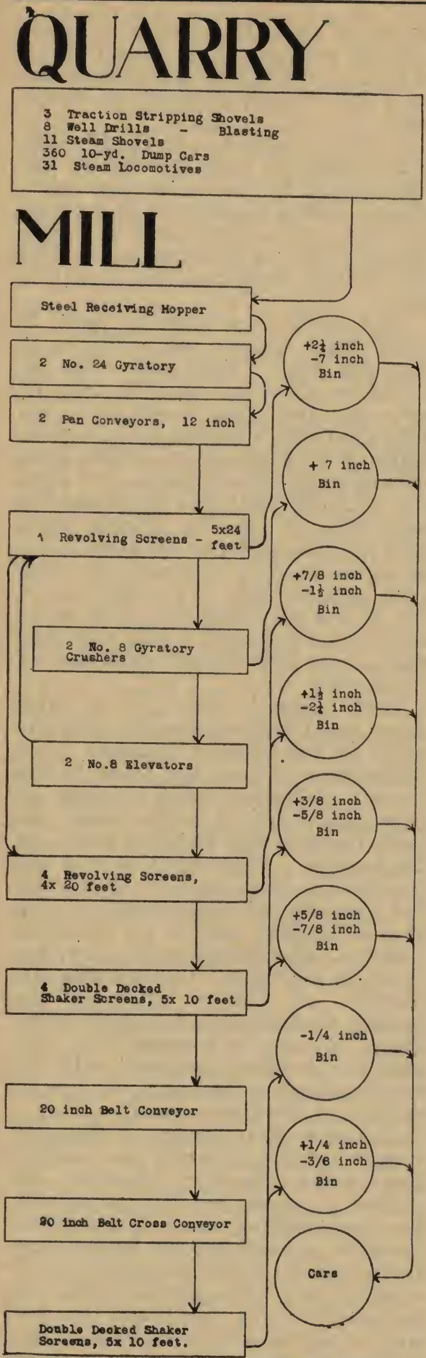
Cars used in hand loading operations are usually of 2 or 3 tons capacity, those employed for taking stone from a steam shovel have capacities of from 5 to 10 tons.

The quarry track system over which these cars are hauled or pushed (at some quarries locomotives push the trains), is usually narrow gauge. In many cases, however, standard guage tracks are laid to meet some condition peculiar to the operation. Where it is required that the cars carry a heavy load, sometimes up to 15 tons, a standard gauge transportation system is in effect. In general, of course, the higher the car, the more advisable it is to have wider gauge track.

The actual capacity of each car, the rate at which the cars must be brought up to the crusher for dumping, the capacity of the shovel, and the size and capacity of the primary crusher, are all factors in successful quarry practice that are intimately connected. The cars must be of such capacity and be operated on such a schedule as to keep the shovel busy. They must also be of such size and be dumped at such frequency as to come up to the capacity of the primary breaker and insure its efficient operation. Stone must be reduced by blasting to sizes that the shovel can load and that the crusher can reduce. In plants of large capacity it is the constant tendency to put in bigger and bigger crushers, so that stone will not have to be reduced by blasting to such a fine degree of fragmentation as formerly, and so that the crusher can reduce anything that the shovel can load.

When trains of quarry cars loaded with stone are hauled away from the working faces they are, depending upon the relative positions of quarry and mill and a number of other local conditions, handled in various ways.

In hillside operations, where the quarry is higher than the plant, cars of stone are ordinarily let down by cable one at a time on an inclined gravity railroad to the plant, the operation controlled by a brake at the top. Usually the balanced car plan is in effect, and the descending loaded car pulls up an empty car. This



Flow Sheet of an Ohio Crushing Plant

method, involving the expenditure of no power at all, is very economical.

A number of track schemes are in use. Sometimes the whole system is double tracked, a set of tracks each for the ascending and descending loads. More often three rails are used and the center of these is utilized in common as the inside rail of two sets of tracks. When such a plan is in effect it is necessary to provide a double tracked section with spring switches in the center of the system to allow cars to pass. In other cases, only two rails are provided above and below this double tracked center section. Where single track systems are installed over the entire length of the incline it is necessary, of course, to provide power to haul up the empty cars.

In quarries below plant level, where inclined railroads are used, similar track systems are installed. There is, however, the essential difference that power must be used in all cases to haul stone to the plant. The balanced car plan is frequently in force, but here the descending car merely compensates for the weight of the ascending car. The stone itself must be hoisted by power. Oftener than in the case of the hillside operations, the work of haulage from a quarry below plant level is handled along a single inclined track and the balanced car plan is not in effect. This is particularly so when the haul is short.

When the dumping is done at the level of the quarry floor or at such distance above the floor as locomotives can reach along an easy grade, cars are usually of the side-dump type and are not uncoupled from the train at the time of dumping. In some cases, to enable the operator to use a large quarry car and at the same time not be put to the necessity of hauling this large car up an incline, the primary crusher is installed at or below the quarry floor level and the reduced product brought up to the plant by skips, elevators, conveyors or special cars. At one quarry in Ohio the operators went to an expense of $40,000 to blast out of the solid rock a pit in which to locate the primary crusher. At another quarry in Pennsylvania the operators installed a crushing plant in the quarry so that they could

more easily convey the stone in crushed form over a railroad line that runs between the quarry and the plant.

Before proceeding to a description of the dumping methods employed at various operations, it may be well to describe another haulage arrangement which, while it is not used in many places, is operating satisfactorily in a number of workings. This arrangement involves the use of an overhead cableway which conveys stone in skips or pans from the working faces to the plant. A track line runs from a point at which the material is to be dumped out across the quarry to a tower on the ledge above the point at which the stone is to be excavated. This tower is usually mounted on railway wheels so that it can be moved from one point to another about the quarry, the whole heavily weighted and, if necessary, secured to deadmen. The haulage line runs out the skips to a point on the track line above where the stone is to be loaded. At this point the skip is allowed to descend to the working. Loaded skips are first hauled up vertically and then horizontally along the track line to the plant. This method of haulage is used to most advantage in very deep quarries or in those with broken or uneven floors along which a track could not be laid without great difficulty. In most cases the overhead cable way does not permit rapid operation and is a dangerous installation because of the possibility of injury to workers from falling skips. At a large South Carolina quarry such an installation is giving satisfactory service.

Quarry cars are built to dump in a number of ways. There are end dump, side dump and bottom dump types and the dumping of each of these types is accomplished by a variety of devices.

The end dump cars may be made to discharge at the front or rear end. Front end dumping is usually accomplished by running the car on a rocking tipple which is pivoted slightly off center and will, when weighted by a loaded car and released by means provided, drop forward, this action discharging the contents of the car. If the car is closed at the front end, the gate closing it is hinged by rods or bars at both sides of the car near the rear and has irons projecting at the sides. These irons touch rails when the car is tipped forward and the rails hold the end gate high while the end of the car is lowered. This leaves the stone free to slide forward out of the car.

A similar method is employed when it is desired to dump the car at the rear end, as is usually the case when a car is hauled by cable up an inclined cableway. The irons touch the rails, which are set at a steeper angle than the inclined track, and thus raise the gate.

Side dump cars may be built to throw their loads to both sides or to one side only. Both sides may be closed by gates or one side may be open and the other walled up solid. This type with one side open may be hinged a little off center so that, upon releasing chains or catches, the open end of the car will drop down and the stone fall out. A side rocking tipple may also be employed for lower, non-pivoted cars, or a steam, air or cable hoist may be used to tip sideways a car of the pivoted type. Side gates are arranged in such a way that they open on the side toward which the car is dumping.

Stone dumped from cars or skips drops into hoppers above the crushers which do the primary breaking. As it is desirable to feed the stone to the crusher endways, apron feeders or long chutes are, in a few cases, installed between the dumping point and the crusher. These tend to thin out the feed of stone, give it regularity, and arrange the large stones in the most convenient position for crushing.

Initial breakers are of the jaw, gyratory or roll types. Considerable differences of opinion exist on the relative desirability of each of these types. All are in common use, with producers perfectly satisfied with the results they are getting from one or another of the three types.

A number of arguments advanced in support of the gyratory are as follows: The gyratory capacity, as against a jaw crusher of the same size feed and product, is much more than twice the capacity of the jaw crusher and the relative power required is only a little more. The greater output is explained by the fact that the jaw crusher exerts simply compressive action while the gyratory introduces compressive and tensile stresses. The

gyratory takes less power because its action is continuous, while the jaw crusher consumes considerable energy in overcoming the inertia of heavy and rapidly reciprocating parts. The gyratory usually gives a more uniform product, the concave shape of the rigid shell of the gyratory breaking some of the product by beam action and causing the material to be more cubical in form than the product of the jaw crusher. The large opening at the top of a gyratory acts as a hopper and keeps an amount of stone always ahead of the crushing surfaces. Crushing shock is more evenly distributed. Vibration during operation is less.

Some of the arguments for the jaw crusher are as follows: It has a wider range of adjustment, the drive is more direct It is easier to repair and to compensate for the results of wear. It requires less head room. There is less actual wear on the liners of a jaw crusher because they have not to withstand a certain grinding action observed in the gyratory. Jaw crusher liners can be reversed, and thus made to give more wear. They are easier on bearings and eccentrics. They handle large stone more readily.

Crushing rolls are of a number of kinds. There are single roll and double roll machines in use. The rolls may be corrugated or fitted with slugger knobs, blunt teeth which catch the edges of the stone and make it possible to apply the crushing force readily. They have wide hopper-shaped mouths that will take large fragments. There is not much danger of the blocking or jamming of stone in roll crushers. They handle the crushing very rapidly.

A number of devices are provided around crushers for moving stones that jam or bridge. Bars do for the moving of stones in most cases, but sometimes it is necessary to use hooks operated by chain blocks, friction hoists or air or steam hoists. It is often necessary to sledge stones to get them through the crusher.

From the crushers the stone is taken, usually by bucket conveyors to the screening department. The stone may go first to a grizzly or to a rotary screen. The first rotary screening operation is usually conducted at the highest part of the plant, gravity being utilized as much as possible from then on.

Rotary screens of many lengths and diameters are employed about crushed stone screening plants. The horizontal axis of such a screen is usually inclined at 7 degrees to the horizontal. The longer the screen the greater is the inclination required, the differences in inclination never in any case becoming great. Material in going through a rotary screen assumes the form of a helix; it travels, rather, in what is practically a helical path. Feeding must be done with care, as both overloading and underloading are undesirable. Overloading, particularly, results in the turning out of an inferior product, as it prevents the working down of the lighter materials to the screening surface until after the stone has gone over those sections of the screen that were designed to pass the small sizes.

A fair proportion of large particles in the stone to be screened helps the screening process to a considerable extent and makes more certain an accurate sizing. Another important truth in screening practice that quarrymen should bear in mind is that the action of a particle of stone in going through the screen should be rolling instead of sliding. Stone should be carried up 45 degrees in the direction of rotation and rolled back. This gives more desirable results than are secured from a sliding mass.

Sometimes it is considered advisable to use two screens where one could be made to accomplish the work, the second screen a smaller one carrying a light load and accomplishing a close separation.

The diameter of the screen has an important bearing on the production expected per hour. Larger diameter screens with more flattened concave surfaces would be expected to thin out the stone going through and thus help the screening process.

Sometimes early in the process a grizzly is used to scalp out the oversize material and send it back to be crushed, or to separate the material smaller than the size to which the primary crusher reduces and thus relieve that machine. The simplest form of this device is the bar grizzly, well described by its name. It consists of a number of bars spaced at distances

determined by the product to be passed and inclined at about 45 degrees with the bars running from top to bottom, the whole giving the appearance of a grate. Stone is dropped on this grizzly from above and the device performs the office of passing the sizes desired and knocking the oversize sideways into a chute running back to a crusher. The difficulty with the device is that it blinds or clogs and requires quite a bit of attention to keep it performing its work efficiently.

There are in use a number of power grizzlies in which this disadvantage is removed. These grizzlies are of the shaking or rotary types. The shaking type grizzly consists of a grill that is agitated continuously and thus kept free. The rotary type is built of a number of rolls with rings that are a part of the rolls themselves running around the rolls at intervals. A series of about five of these rolls placed side by side with the rings touching, the whole assembly at an angle of about 45 degrees and with the rolls all rotating vertically, is said to give very efficient service.

From the scalping screens the stones go a number of ways, as determined by their sizes Those passing the rings of the scalping screens go to bins, while the oversize is chuted back directly for crushing. Arrangements for secondary crushing and rescreening are in most cases quite intricate and differ with the particular requirements of individual plants. *A crushing and screening installation must be as flexible as possible, so* that, by arranging the flow of stone sizes in one direction or another, it will be possible to get a production of the materials most in demand and keep the output balanced as closely as possible against requirements.

Secondary screening is done by smaller rotary screens, by shaking screens, or by vibrating screens. The shaking screen utilizes a backward and forward movement of the entire screen structure which consists of a flat screening cloth bound in a framework, the screening surface inclined slightly to the horizontal so as to induce a forward progress of the stone. The vibrating screen employs a motion that causes the stone to be bounced by the screening cloth and thus, if it be of proper size, to find its way through the openings of the screen. In some vibrating screens the motion is applied to the center of the screening cloth by a vibrating member, in others the vibratory motion is applied to the frame in which the cloth is bound, and through this frame applied to the cloth.

The logical and economical location of each crusher and screen in a modern crushing plant can hardly be discussed in a general way. These are matters that must be decided to a considerable extent by the local conditions at each plant. It may be said that the general tendency is to get further and further away from the former almost universal practice of using one crusher to a quarry, returning the tailings to this machine to be crushed. The flow sheet of a modern crushed stone plant with its batteries of large and small crushers for the production of various sizes, is very complicated and exhibits the result of painstaking care in design and a continued working toward greater and greater flexibility of operation. If one of the crushers in a modern plant breaks down it is possible to divert the flow of stone in a number of ways and thus secure a production which, while affected by the broken machine, is not disorganized.

Gravity, of course, is utilized as much as possible in the progress of material through a plant, but continued re-elevating and conveying of stone cannot be avoided. Belt conveyors, bucket conveyors and elevators are found performing many offices.

The reduction of limestone to sizes that make possible its sale as agricultural limestone, chicken grit, etc., is handled by the pulverizing department, where rather different methods are in effect.

Stone intended for pulverization is usually dried first. This operation is accomplished by means of a rotary dryer which applies the hot air and gases of combustion directly to the material. After coming from the dryer the stone is passed to bins, from which are fed the pulverizers that reduce the stone to the size required. Chicken grits are furnished in a number of sizes between 1/16 inch to 1/4 inch and agricultural limestones in a great variety of finenesses running up

to 85 per cent through 200 mesh. The fine reduction is ordinarily done in a tube mill. The stone after this is passed on to bins which feed packing machines that put the product up in accurately weighed packages.

Where pulverizing equipment is used, and with the larger crushing machines too, magnetic separators are frequently employed. In its most usual form the magnetic separator is a pulley, containing a core that is kept magnetized by the action of a direct current. A conveyor belt carrying stone on its upper run toward this pulley is free to discharge in the regular way over the pulley only nonferrous material or material containing no iron. If "tramp iron" (coupling pins, spikes, tools, etc.) is mixed in with the stone, it comes under the influence of the magnetized pulley and is pulled around out of the path of the stone that is being discharged from the belt, getting out of the magnetic influence only when, clinging to the under side of the belt, it reaches a point where it may safely be deposited. Thus it is prevented from getting into the pulverizers or crushers and doing serious damage. Single accidents caused by tramp iron to reduction equipment have frequently cost thousands of dollars and many operators have installed these magnetic separators to guard against such eventualities in their cases.

When the producer has too much of one particular size of stone at one time, he stocks it in piles on the ground. He also builds up each fall a reserve of stone for sale during the winter months when his plant is shut down. The work of building up and reclaiming from a stock pile is done in quite a number of ways.

A very economical method of stocking out is by means of a belt conveyor running on a trestle above the area in which the piles are to be made. This conveyor takes material at the plant and, through the agency of a shuttle, scraper or tripper, deposits it where desired. Sometimes the belt galleries are covered, sometimes open.

The locomotive crane is often used in stocking out. Its advantages are that it serves both for stocking and reclaiming, that its first cost is low as compared with other systems, and that it deposits sizes on the pile just as it picks them up, without running the larger sizes to the outside of the piles. The operating cost of the locomotive crane is higher than that of the belt conveyor.

The aerial cableway necessitates a large installation cost, but is comparatively inexpensive to maintain. It is used to a considerable extent in large stock piling operations.

The gantry crane also carries with it a considerable installation cost and is intended for big piles.

The stationary revolving crane equipped with two arms builds up a round stock pile and must, because of its large installation and operating costs, deal with very large capacities.

The pivoted bucket conveyor is another stocking out device that operates on the general plan of the belt conveyor, except that the deposition of material is accomplished by the tipping of the buckets at the proper places instead of the scraping of the materials from a belt.

A New York state quarry has had very satisfactory and economical service from a single line aerial cableway system installed about 25 years ago. It has proved easy and cheap to maintain, requiring nothing but power, a labor charge for 2 men and the cost of keeping the bucket in repair.

In some places stocking out is done by pushing small cars out along a trestle by hand and dumping them at desired locations. The plan would not appear to be economical.

Reclamation from stock piles is accomplished through locomotive cranes, tunnel belt conveyors below the piles, power scrapers, portable loaders and a number of other devices.

Ground on which stock piles are to be built may be prepared by surfacing with asphalt, concrete or some other solid and durable materials. Planks have been used in many cases but have often proved unsatisfactory. An operator who is willing to leave a certain part of his stone remain on the ground is thus furnished with a pavement.

Stone in the bins is loaded into railroad cars through slide or clamshell gates at the bottoms of the bins or through spouts at the sides of the bins. The greater part of the stone prepared is shipped in railroad cars, but most plants have a considerable

truck business, too. Some plants serve trucks only, but they constitute a small minority, and are individually small.

Some crushed stone men operate in conjunction with their quarries and crushing plants other plants that utilize the by-products of quarry operation. In a number of places now operators are manufacturing concrete brick from cement and the screenings left over after their processes are completed. This is proving a very useful means of disposing of what is otherwise a nuisance. Some operators are able to dispose of their screenings to Portland cement mills; others not so fortunately situated find the manufacture of concrete brick profitable and, through the reductions of the screening pile, otherwise advantageous.

Manufacture of Portland Cement

Portland cement is defined as "a hydraulic cement consisting of compounds of silica, lime and alumina. It is obtained by burning to semifusion an intimate mixture of pulverized materials containing lime, silica and alumina in varying proportions within narrow limits, and by pulverizing finely the clinker that results." The name "Portland" was given to this hydraulic cement by its inventor, Joseph Aspdin, because of a resemblance that he believed he saw between the natural oölitic limestone of Portland, England, and concrete made from his cement. Aspdin, a brick mason of Leeds, England, was granted a patent on his method of manufacture in 1824.

The union of lime, silica and alumina which forms Portland cement is brought about in a number of ways. In some sections it is necessary merely to burn a natural cement rock, an argillaceous limestone which in addition to the lime contains the other essential substances and merely requires the application of heat to produce semi-fusion, and possibly the introduction of pure limestone to correct the proportions. Some blast furnace slags also contain close to the correct proportions of the various constituent materials. In most sections of the United States where Portland cement is produced, however, it is necessary to employ a more roundabout process and to operate with a greater number of raw materials.

The methods in use at the present time involve the union by heat of lime, silica and alumina furnished by the following combinations:

(1) Limestone + clay or shale
(2) Cement rock + limestone
(3) Chalk + clay or shale
(4) Slag + limestone
(5) Marl + clay or shale.
(6) Alkali waste + clay

Of these methods the one most practised today is that involving the fusion of a limestone or chalk with a clay or shale. The cement rock and limestone process, which was up to 1906 the most important, has since been steadily losing its position in spite of the fact that greater quantities of cement are produced each year in this way. Production of cement by the fusion of limestone or chalk with clay or shale has greatly increased in importance through the establishment in all parts of the country of plants employing this process.

When limestone (calcium carbonate, $CaCO_3$) is utilized as the lime producing material, the result is secured by the burning of the $CaCO_3$ to expel carbon dioxide (CO_2), leaving lime (CaO). This lime unites with the alumina and silica contained in the clay or shale. Absolutely pure clay is a hydrated silicate of alumina, known as kaolin (Al_2O_3, $2SiO_2$, $2H_2O$). Such a pure clay is not available for the manufacture of cement, neither is the limestone ordinarily free from impurities of a number of kinds. The formulae given above are intended merely to show in a general way the reaction that takes place. Detailed accounts of all parts of the process will be found later in this article.

In this broad preliminary consideration of the materials used in cement manufacture, the terms clay and shale may be used interchangeably. Shales are clays changed by pressure to the condition of rock. Slates, too, belong to the same group. They are an extension of the condition of the shales; that is to say, are clays turned to rock, but to more consolidated rocks, because the pressure applied to them was greater. They have a laminated structure and the property of splitting into thin sheets. They are not used extensively in cement manufacture.

Clays have their origin in the disintegration and decay of rocks. When the clays are found at the place where the original disintegration and decay took place they are known as residual clays; when found at a place to which they have been carried by water movement, they are termed sedimentary clays; when they occur in a given locality as a result of transportation by the action of a glacier, they are called glacial clays. Of these three kinds the most desirable for cement manufacture are the sedimentary

clays, this because of the fact that in their travel by water they have lost all the undecayed remains of the rocks from which they originated and have not acquired any foreign materials such as sand and gravel. The residual clays often contain fragments of quartz, limestone or flint, depending upon the rocks from which they originated. The glacial clays in the course of their long travels at the toe of a glacier pick up a great deal of rock material of all kinds. Sedimentary clays are easily recognized by their homogeneity and fine grain, residual clays by the fact that they contain rock fragments of one kind or another, glacial clays by their association with rock fragments of diverse characters.

The same differences that exist between the clays, shales and slates, differences in the degree of consolidation of the materials, exist also as distinguishing features of the lime producing materials, which are, in the order of their hardness, limestones, chalks and marls. Slags and alkali wastes are not mentioned in this group because they are not found in nature as such. They are artificial products and will be touched upon in a class by themselves.

The limestones are the most highly consolidated substances in this group of lime producing materials. They are formed as a result of the deposition on ancient ocean bottoms of the calcareous remains of marine organisms or of a throwing of solution of the materials held in the waters of these prehistoric seas. In many places the organic origin of the limestone can be readily seen from the prevalence of fossil remains. Many existing limestone deposits indicate, too, the former presence of evaporated oceans of which the present day limestone is the only residue.

The hardest, most highly consolidated form of limestone, is marble, a metamorphosed and recrystallized limestone. Expressed in more simple language, marble is a limestone that has been acted upon by the outside forces of heat, moisture and pressure, has been softened, compressed and then made to crystallize into the substance that we have today.

The next group in the scale of hardness are the limestones proper, which occur in many forms as stratified deposits, but include also such materials as travertine and tufa, which form the stalactites and stalagmites of caves and the filling of some veins and spring conduits. Many of the lime producing stones, such as dolomite, a limestone containing about 40 per cent magnesia, are not of interest to cement producers.

The next descending stage of hardness is represented by the chalks. Chalks are fine-grained and very pure limestones that have their origin in the calcareous (limestone containing) shells of microscopic organisms, notably of the Foraminifera. They have the advantage in Portland cement manufacture of a high lime content and a low resistance to a crushing force. These desirable features go far to overcome the disadvantage that chalk has of absorbing water too readily.

After the chalks in the order of consolidation are the marls, a term that must be understood to include only fresh water marls and to exclude a number of classes of material that might quite correctly be grouped under the term "pseduo-marls." This term is merely one used by the writer and must not be understood as a geological designation in good use. These classes of so-called marl materials above mentioned include the green sand marls of Virginia and New Jersey which are not true marls but iron silicates containing small quantities of calcareous, argillaceous and phosphatic matter. Allied to these are groups of calcareous shales which have been variously called marls or marlytes, also certain unconsolidated limestones in the eastern part of the United States that are argillaceous or phosphatic in character. These three classes of marls are of salt water origin and do not exhibit the characteristics of marls suitable for the making of Portland cement. A rather indefinite nomenclature surrounds the subject of marls, at least in this country.

The true or fresh water marls are relatively pure calcium carbonates. Their origin is still a matter of doubt among geologists, though most occurrences of the substances show forth certain facts of their early history

very clearly, and these facts point to a glacial origin.

Fresh water marls are found in the beds of extinct and existing lakes in lenticular or basket-shaped deposits. The material was brought by glaciers to the places where it is at present found. These glaciers brought down great amounts of very fine calcareous material and formed the lake basins in which the marls are at present found. The exact manner of the formation of the marls is not so clear. It is not known whether they are due entirely to a deposition of calcium through purely physical or chemical agencies or partly through the action of certain vegetable or animal life. Vegetable life appears, in an indirect way, to be an important agency in the formation of marl.

The marl itself is a soft friable material containing, together with iron, lime and organic impurities, occasional small amounts of sulphur. The lime carbonate content usually analyzes about 90 per cent, with less than 1 per cent of silicon dioxide and less than 1 per cent of aluminum oxide and iron oxide combined.

Besides these raw materials that are found in nature there are a number of others which come to the Portland cement manufacturer as by-products of outside industries. One of these is alkali waste and the other blast-furnace slag. In most cases there is a connection between the ownership of the Portland cement plant and the ownership of the plant producing the by-product that is used as a raw material in Portland cement manufacture.

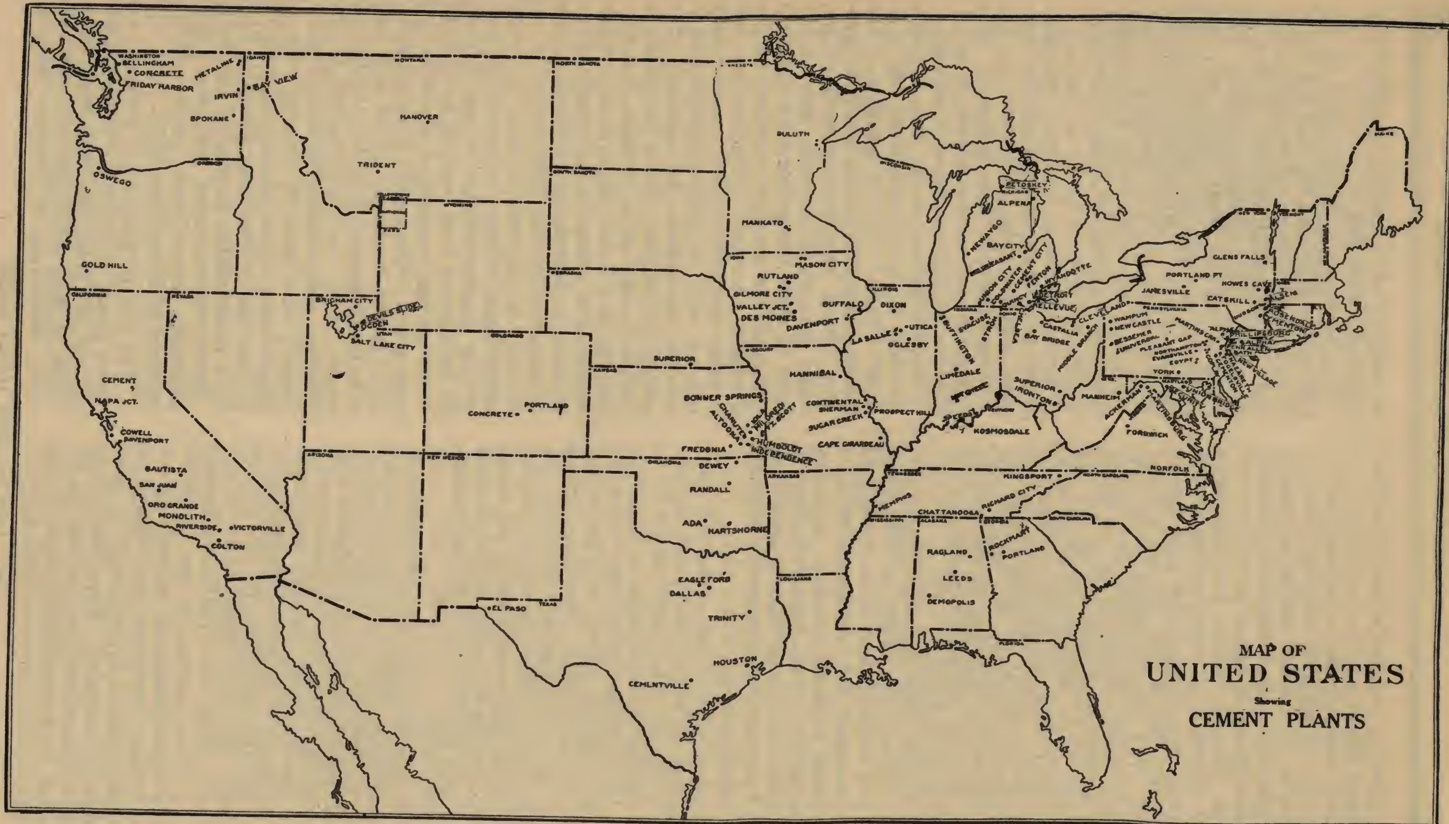
Alkali wastes of various kinds contain material needed in the manufacture of cement, but many of these alkali by-products are combined with impurities which render them unfit for use as Portland cement materials. An example of an alkali waste unsuitable for the manufacture of Portland cement, is that secured as a by-product from the LeBlanc process. The LeBlanc process is one in which, in the manufacture of sodium carbonate, sodium sulphate is reduced to sodium sulphide by heating with charcoal and limestone. The alkali waste is a very pure calcium carbonate occurring as a precipitate. This waste, however, often contains large amounts of sulphur as sulphides, making this material unsuitable.

The ammonia process yields an alkali waste that can be used for making Portland cement. This waste is a pure precipitated calcium carbonate associated with calcium hydrate. The sulphur content runs very low, not sufficient to cause any difficulty to the manufacturer. Other characteristics of the waste, such as magnesia content, are dependent upon the character of the limestone used in the ammonia process.

Portland cement has been manufactured in Europe from Le Blanc process alkali waste, but never in the United States. One plant in this county manufactures cement from alkali waste of the ammonia process.

Blast-furnace slags are silicates formed by the combination of limestone fluxes with the gangue of the metallic ore during the smelting process. When this gangue contains alumina in connection with iron in the form of oxides, together with sufficient silica, all the constituent materials for Portland cement manufacture are present in the slag and require only mixing with corrective quantities of needed materials to produce the proper mixtures. Lime in slags is present as an oxide instead of a carbonate, and hence requires the application of less heat than is needed when the lime is introduced in the kiln as a carbonate. The disadvantage in the use of slag is connected with this very advantage. Clinker produced by calcining slag is very hard and difficult to grind, and is commonly granulated by being run in a heated condition into cold water. The result of this immersion is the breaking up of the slag into small porous granules and the removal of a considerable part of the sulphur. The disadvantageous feature then shows up. In the process of granulating the clinker by immersion in cold water, the little granules pick up a considerable amount of the water and this necessitates the use of considerably more heat in the drying process which follows later.

The use of slag as a Portland cement material, has the desirable feature of not requiring very large quantities of any other material than the slag, assuming, of course, that the


MAP OF
UNITED STATES
Showing
CEMENT PLANTS
BELLINGHAM
CONCRETE
FRIDAY HARBOR
METALINE
IRVIN
BAY VIEW
SPOKANE
HANOVER
TRIDENT
OSWEGO
GOLD HILL
BRIGHAM CITY
DEVILS SLIDE
OGDEN
SALT LAKE CITY
CEMENT
NAPA JCT.
COWELL
DAVENPORT
BAUTISTA
SAN JUAN
ORO GRANDE
MONOLITH
RIVERSIDE
VICTORVILLE
COLTON
CONCRETE
PORTLAND
EL PASO
SUPERIOR
DULUTH
MANKATO
MASON CITY
RUTLAND
GILMORE CITY
VALLEY JCT.
DES MOINES
BUFFALO
DAVENPORT
DIXON
LA SALLE
UTICA
OGLESBY
HANNIBAL
BONNER SPRINGS
CONTINENTAL
SHERMAN
PROSPECT HILL
SUGAR CREEK
CAPE GIRARDEAU
FREDONIA
HUMBOLDT
INDEPENDENCE
DEWEY
RANDALL
ADA
HARTSHORNE
EAGLE FORD
DALLAS
TRINITY
HOUSTON
CEMENTVILLE
ALPENA
PETOSKEY
NEWAYGO
BAY CITY
DETROIT
WYANDOTTE
BELLEVUE
BUFFINGTON
LIMEDALE
CLEVELAND
CASTALIA
BAY BRIDGE
SUPERIOR
IRONTON
KOSMOSDALE
MEMPHIS
KINGSPORT
RICHARD CITY
CHATTANOOGA
ROCKMART
PORTLAND
RAGLAND
LEEDS
DEMOPOLIS
NORFOLK
FORDWICK
MANHEIM
YORK
WAMPUM
NEW CASTLE
BESSEMER
UNIVERSAL
PLEASANT GAP
NORTHAMPTON
EVANSVILLE
EGYPT
GLENS FALLS
PORTLAND PT
HOWES CAVE
JAMESVILLE
CATSKILL
ROSENDALE
PHILLIPSBURG

slag is one which contains close to the requisite proportion of Portland cement materials. At the present time there are a number of plants in the United States employing this process and there is no reason to believe that it will not come more generally into use.

Slag is used in the manufacture of two other cements, and these must be clearly distinguished from the true Portland cement which is the only material of this class under consideration in this article. One of these slag cements is made by grinding slag with hydrated lime, employing no later calcining action. This material is a puzzolan cement. There is also a German "iron-Portland" which is produced by introducing 30 per cent by weight of granulated blast-furnace slag into true Portland cement.

This completes our brief description of the materials from which Portland cement is manufactured. We will next take up the consideration of the methods used in producing these raw materials, thus carrying us up to the point of actual cement mill operation.

The first material in importance is naturally limestone. Methods used in quarrying of this material are described in detail under the heading of "Crushed Stone." This limestone, like most materials used in the making of Portland cement, is secured largely by open face quarry methods. A considerable amount of material is also secured from underground workings as in cases where straight mining, stoping or glory hole methods are employed. As the material must be selected with more care than in the production of crushed stone, it is often expedient to resort to methods of this kind to secure Portland cement material when these methods would be too costly for the production of limestone aggregate.

There is observable around Portland cement limestone quarries, the same diversity of operating methods that can be seen at any other limestone operation. Workings are benched or "single face." Development is either downward or lateral, and the other features of the operation vary with the local conditions, just as do the features of all limestone workings. Methods used in securing the other rock materials employed in Portland cement manufacture follow the same general lines as in limestone quarrying, except that the materials are easier to excavate than the general run of limestone. Chalk, for example, is drilled, blasted, loaded and crushed much more easily than the denser limestone.

Marls and clays are produced by rather different methods. Excavation in these cases is mostly by steam shovel or dipper dredge work. At one marl producing plant very efficient production is gained by working an under-water deposit with drag line cableway.

Marl is in many cases secured by dredging. Clay, too, is sometimes taken from under-water deposits, but seldom except where the clay and marl occur together in the same deposit. The marls are secured by dredging methods, a dipper dredge often being employed. This equipment is nothing more than a steam shovel on a barge, provided with suitable spuds to anchor the craft to keep the swinging of the dipper from side to side from rocking the craft too much. This dipper discharges the excavated marl on a scow alongside or into dump cars if these can be brought close enough to the working. There is another method of conveying the excavated material which calls for dumping the marl into tanks and after the addition of sufficient water to make it flow readily, pumping the mixture to the mill through a line of pipe.

Cement mills are located as near as possible, of course, to the raw material sources and the ideal location, in this respect at least, is one in close proximity to the deposits of limestone, shale, clay, marl or chalk employed in the process. But proximity to supplies of raw material is not the only or even the most important factor in determining upon a location. Other raw materials that do not enter into the product itself are used in great quantities and these must be available if the mill is to operate profitably. Fuel must be close at hand, for it is used in prodigious amounts. There must be good transportation facilities to the markets that the mill is intended to serve and these markets must be broad and dependable.

In most cases mills are located close

to the quarries or pits from which the raw materials are secured, but in other cases one or another of these materials must be hauled over long distances. This seemingly great disadvantage is accepted by the owners that the mills may be located closer to their markets and to dependable fuel supplies.

Each 1,000 barrels of cement produced daily will require, on the basis of 300 days operation per year, a yearly supply of 67,500 tons of limestone and 22,500 tons of shale or clay, or equivalent quantities of other materials. This means that for each 1,000 barrels of cement turned out daily the company's quarries will be depleted yearly to the extent of 20 acre-feet of limestone and 8½ acre-feet of shale or clay; that is, material will be taken from one acre of each of the properties to the depths given above. It is thus possible, after the properties have been carefully prospected, to estimate how long the deposit will hold out. It is unwise to begin operations with less than a 25-year supply of material available.

At some quarries the practice is to reduce the rock to crushed stone before sending it on to the mill proper, but in most cases the material is sent direct to the mill from the quarry. Some operations, too, include the drying of the stone at the quarry and shipping it in the dried state to the mill. This is not practised in many places.

Portland cement mills in this country fall into one of two general classes, "dry" plants and "wet" plants. Neither of these, it is true, properly includes plants operating with blast furnace slag, but the production obtained by this method is a comparatively small part of the total and will be considered as a separate class.

The distinguishing feature of a dry plant is that it calls for the removal early in the process of any free moisture contained in the ingredients. Usually both raw materials are first crushed to small size and dried separately. They are then mixed intimately in the correct proportions and pulverized together, this last operation completing the mixing process. The mixture is then calcined and the resulting "clinker" crushed.

Operation of a wet plant includes mixing and grinding the constituent materials in a wet state, this action producing a "slurry" which is sent to kilns and calcined. It antedates the dry process, but went out of use to a considerable extent with the advent of the rotary kiln which added certain advantages to the dry process of manufacture. Of late, though, the wet process, modified and improved, has been adopted as better suited to certain classes of material than the dry. As will be seen later the longer kilns that are steadily coming into use give it an opportunity to compete favorably with the method which supplanted it a number of years ago.

In general, but only in general, the wet process lends itself better to operations where marls and some clays and chalks are used, or where the materials are irregular in composition. The dry process is more in use where materials of regular composition, that are dry or can easily be dried, are employed. The wet process saves the cost of drying the raw materials, is conducted at a lower cost for power used in grinding, permits more accurate correction of the mix before calcination and simplifies the task of keeping the final product uniform. On the other hand the wet process necessitates a higher fuel consumption, although this disadvantage diminishes as longer and longer kilns are used.

In the typical plant employing the dry process the first step is the reduction of the rock to suitable size for handling in the driers. This matter of the crushing is taken up in the article on "Crushed Stone," which appears on earlier page. It is accomplished by the use of gyratory or jaw crushers, roll crushers, etc. Screens are used to make the proper separations and the crushed stone goes ahead to rock storage bins which are drawn upon later to feed the dryers.

The work of drying the stone varies, of course, with the amount of water to be driven off; and this is dependent upon the weather, handling conditions and the character of the material. Absorbent materials, like chalk, will take up water readily and all stones will acquire some if exposed to the weather, wet quarry conditions, etc. Where marls are utilized

in the dry process the drying operation is much more difficult, for the water to be driven off runs around 50 per cent of the entire substance.

The rotary dryer is chiefly in use. This is sometimes heated by waste kiln heat, sometimes by a furnace installed in connection with it. The heat is introduced at the lower end of the tilted cylinder and is drawn through its entire length. The stone is introduced at the higher end, finding its way to the lower end as the dryer revolves. Flights and lifters are usually attached to the inner surfaces to insure more thorough agitation and greater exposure to the action of the heat.

Clays are first dried by air, this method reducing the free water to as low, sometimes, as 1 per cent. Water in chemical combination, which ranges from 5 to 12 per cent, is driven off only by raising the clay to red heat.

After the drying operation has been completed, the two materials are mixed at once or ground separately and then mixed. Mixing is accomplished mechanically, the quantities of each material being automatically weighed or measured to secure the proportions established for the particular batch going through at the time. These proportions are determined by a chemist who keeps accurate check of all the raw stock that enters the mill.

Chemical calculation and control of the mix at Portland cement plants is an important feature of the work and contributes largely to the final result. Portland cement is a standardized product and each mill produces a cement that measures up with slight and, in fact, negligible variations from the formula for an ideal product. This can be done only after the most painstaking care has been given to combining the component materials.

One of the actions that takes place in Portland cement manufacture is the union of lime and silica to form a tricalcic silicate ($3CaCO,SiO_2$) from which the cement largely derives its hydraulic properties. The percentage composition in this case is lime 73.6 per cent and silica 26.4 per cent, meaning that the lime and silica are to be combined in the proportions of *lime 2.8 to clay 1. This compound, however, cannot be produced at the heats attainable by Portland cement* kilns. The lime and silica will not fuse or "clinker" by themselves except under intense heats, which it would not be practical to employ commercially. These two substances must be heated together with other materials which will serve as fluxes in aiding combination. This last useful purpose is served by alumina and the iron oxide which is often associated with it. These are contained in the raw materials themselves. In calculating the mix the chemist has to take these into consideration.

Then, too, with the lime is often associated an amount of magnesia which must be reckoned with. Study of the subject has established an index figure to be used in connection with the figure representing the percentage of magnesia, and other index figures on the order of the two above (lime 2.8, silica 1) to be used in connection with the figures representing the percentage of alumina and iron oxide.

How these index figures aid in determining a mix are shown by their employment in Eckel's Cementation Index.

$$\frac{(\text{Percentage lime})+(1.4\times\text{percentage magnesia})}{(2.8\times\text{percentage silica})+(1.1\times\text{percentage alumina})+(0.7\times\text{percentage iron oxide})}$$

These figures are applied in a slightly different way by Professor Newberry, who gives in detail the following rule for calculating mixes. These rules are based upon an assumed ideal mill operation, thorough grinding, mixing, calcination, etc.

Operation 1.—Multiply the percentage of silica in the clayey material by 2.8, the percentage of alumina by 1.1 and the percentage of iron oxide by 0.7; add the products; subtract from the sum thus obtained the percentage of lime oxide in the clayey material plus 1.4 times the percentage of magnesia and call the result **n.**

Operation 2.—Multiply the percentage of silica in the calcareous material by 2.8, the percentage of alumina by 1.1 and the percentage of iron oxide by 0.7; add the products and subtract the sum from the percentage of lime oxide plus 1.4 times the percent-

age of magnesia in the calcareous material, calling the result **m.**

Operation 3.—Divide **n** by **m.** The quotient will be the number of parts of calcareous material for one part of clayey material.

Operating with this rule, the cement mill chemist would first set before himself the tabulated result of analyses he had made of a batch of clayev and a batch of calcareous material. Assume that his findings were as follows:

	Limestone Pctgs.	Clay Pctgs.
Lime	51.4	1.8
Magnesia	1.4	1.4
Silica	2.2	60.4
Alumina	2.1	16.9
Iron Oxide	0.4	4.6
Alkalies	0.6	1.0
Sulphur Trioxide	0.5	1.9
Water, carbon dioxide, etc	41.4	12.0
Totals	100.0	100.0

The chemist would proceed as follows to apply Prof. Newberry's rule:

Operation 1.—(Clay)

Silica	(60.4x2.8)=	169.12
Alumina	(16.9x1.1)=	18.59
Iron Oxide	(4.6x0.7)=	3.22
		190.93
Lime	(1.8x1.0)=	1.80
Magnesia	(1.4x1.4)=	1.96
		3.76

190.93-37.6=187.17=n

Operation 2.—(Limestone)

Silica	(2.2x2.8)=	6.16
Alumina	(2.1x1.1)=	2.31
Iron Oxide	(0.4x0.7)=	.28
		9.75
Lime	(51.4x1.0)=	51.40
Magnesia	(1.4x1.4)=	1.96
		53.36

53.36-9.75=43.61=**m.**

Operation 3.—(Determination of mix)

187.17 ÷ 43.61 (**n** ÷ **m**)=4.29 (parts of calcareous substance to be used with one part by weight of clayey substance.

The result given by the above method represents the maximum amount of calcareous material that can safely be used and it is customary to reduce the figure somewhat, say about 10 per cent. In the example worked out above the inclusion of a safety margin in the calculation would give the final results of 3.86 parts of calcareous material to 1 part of clayey. These corrected proportions would keep the mix within entirely safe limits.

As to the office of the component parts that make up both the lime and clayey constituents. It has already been stated that the basis of the final products is tricalcic silicate, formed by the union of the calcium and silica, and that the characteristics of this substance are affected by the presence of other substances, such as alumina, magnesia, iron oxide, etc. All these facts show the necessity for an accurate proportioning of ingredients. The more inaccurate the mix, the greater the quantity of uncombined materials and the greater the danger of imparting undesirable properties to the final product. If too much lime is added there will be uncombined lime in the cement, if too little there will be uncombined silica and alumina. Of these the more deleterious is lime and for this reason the safety margin calculated in the formula above was employed. If plant operation could be made as accurate in practice as it is in theory there would be no need for the safety margin. But it is not; mixing, grinding, and calcination can only be performed on a commercial scale to a degree close to perfection but not quite attaining it. And so the proportion of lime is held down.

In general, the presence of too much uncombined silica and alumina in the final cement tends to lessen the tensile strength of the product. The addition of lime up to the point where it is all properly combined has the effect of strengthening the cement. In our consideration of kiln practice a little later on in this article we will discuss the way in which hard burning aids in the "digestion" of lime and, although at greater cost, results in a stronger product.

The question of allowable propor-

tions of magnesia in association with lime has furnished a subject for controversy for quite a number of years. Later experiments have established the fact that the magnesia may run as high as 10 per cent, although it was at one time thought that it could not safely go above 3 per cent. However, the care given to mixing, grinding and burning must be greater in direct proportion to the added quantities of magnesia. At present the magnesia limit of American Portlands is set at 5 per cent.

The strength of the concrete made from cement is supposed to depend largely upon the amount of calcium trisilicate contained in the cement, and the increase of silica content within certain limits adds, therefore, to the value of this final cement mill product. With the advantages, however, that accrue with increased silica content are concomitant disadvantages that result from the presence of decreased amounts of alumina and iron oxide. The decrease of these constituents makes the cement hard to clinker, but minimizes this last advantage to an extent by making the cement slower setting.

The presence of large or small proportions of calcium aluminate has a direct influence upon the initial setting properties of the cement, the greater amount of the substances causing acceleration of the set, the smaller retarding of the set. Insufficient alumina in the cement will, as above stated, make the mass hard to clinker; too much alumina on the other hand, gives a very sticky clinker.

The presence of alumina in cement is believed to be the material which causes the destruction of concrete by sea water. Le Chatelier has evolved an elaborate theory on the manner in which the destructive action takes place, and has demonstrated that the substitution for aluminous compounds of oxides of iron, cobalt, chromium, etc., results in a concrete more resistant to the action of sea water than the ordinary Portland cement containing alumina.

Frequently associated with alumina in the materials employed in Portland cement manufacture are small amounts of iron oxide. The action of this material is nearly supplementary to that of the alumina with which it is associated and may be considered chemically as an addition to the amount of alumina present, allowing of course for the differences in combining weights. As mentioned above, Le Chatelier has produced Portland cements in which iron oxide was substituted for alumina.

A small amount of phosphorus and alkalies are also encountered in the handling of Portland cement materials. The phosphorus occurs as a lime phosphate and is present in some of the less consolidated materials such as soft limestones, and the so-called marls of the South. The alkalies, occurring as soda and potash, are derived principally from clays and shales. The question of their influence on the cement is still a mooted one.

Sulphur is met with in one or another of the materials entering into the cement mixture, when these materials include pyrites or gypsum. The effect of these sulphur compounds is that of a retarder. The sulphur content is also increased to some extent by the hot gases utilized for calcining the mixture. On the other hand, sulphur trioxide present in the mix is driven off, if the flame is sufficiently oxidizing.

When all these features of the raw stock have been taken into consideration and the mix has been calculated, the quantities of each material are automatically weighed or measured to secure the proportions established. They are then, while thus intimately mixed, passed on to the raw grinding department of the mill.

At this point occurs one of the most important operations in the entire process and one which influences directly all the other actions that takes place. Unless grinding is done thoroughly, proper calcination cannot take place and the finished product will not come up to the high standard maintained by all Portland cement manufacturers. It is absolutely necessary in order to secure a volume-constant cement. The finer the grinding the more intimate the mixture and the better the chances offered for the component parts to unite under heat into one substance of even composition.

The higher the percentage of lime in the mixture the finer must that mixture

be ground. The bad effects of free lime in cement, above a certain point, have already been pointed out and it is easy to see how very fine grinding will reduce the chances for the occurrence of this undesirable substance.

Fine grinding tends to overcome defective mixing by working together very intimately materials that may not have been thoroughly mixed. In plants operating on cement rock this beneficent result of thorough grinding does not show up so much, but becomes more noticeable as the materials become more dissimilar in chemical or physical properties.

A carefully conducted and effective grinding operation has the effect, also, of cutting down the burning time. Modern demands necessitate the production of cement in as short a time as possible and this can be done only when the kilns are fed finely divided materials upon which their heat can be expended as quickly and thoroughly as possible.

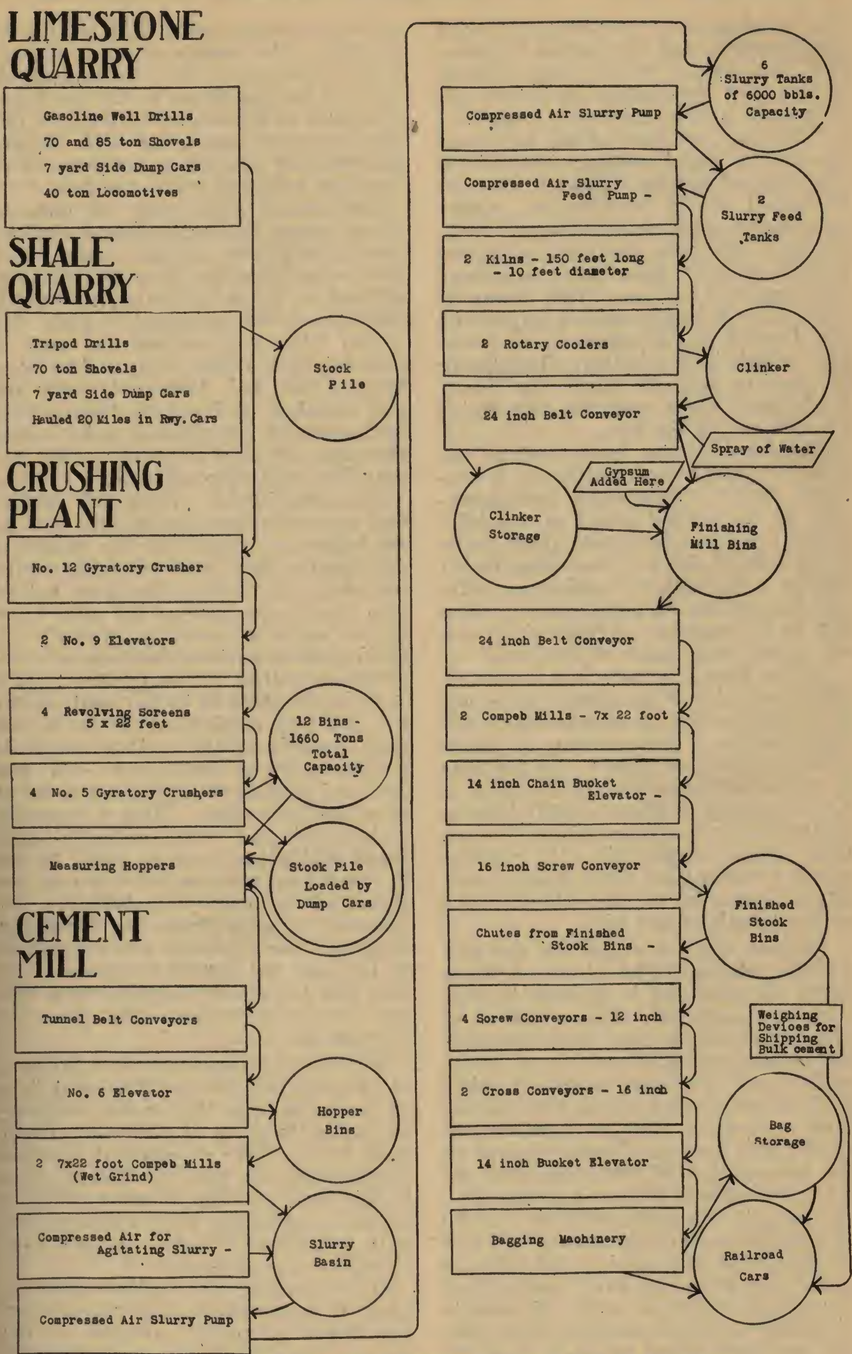
The average raw ground Portland cement mixture will run 85 per cent through a 200 mesh screen, although it will not reach this fineness in plants where the necessity for painstaking care in the grinding does not exist.

The types of grinding machinery in use around cement mills are so numerous that they can in this article merely be listed. They are used in many combinations and individually satisfy various conditions peculiar to the mill, the raw stock or the product desired. This group of equipment includes rolls, millstones, buhrs, edge runners, dry pans, centrifugal grinders such as ring rolls, ball grinders such as the tube mills and ball mills and impact pulverizers. The rolls crush the material between plain, fluted or toothed cylinders; millstones and buhrs utilize two flat or grooved discs, one of which revolves; edge runners and dry pans crush the material in a pan under a cylinder gyrating about a vertical axis and turning about a horizontal axis; centrifugal grinders, such as the ring roll, do the work between rollers and an annular die, against which the rollers are pressed by centrifugal force; tube mills and ball mills utilize pebbles rolling loosely in a revolving horizontal cylinder; impact pulverizers or swing hammer mills operate by delivering blows with revolving bars, cups or hammers.

After the raw mixture has been thoroughly ground by one or a combination of the above pieces of pulverizing equipment, it is passed on to kilns, where calcination takes place. The rotary kiln is used almost universally in this country, supplanting the vertical kilns used originally in some of the older plants. There are a few vertical kilns still in this country, but the plants employing them are coping with unusual conditions which make their use advisable. The rotary kiln is a steel cylinder set at an inclination of one-half inch to the foot, and rotating on bearings. Portland cement kilns are continually being built in larger sizes, some of them today running up to as high as 250 feet in length, with diameters of 10 and 11 feet. In general, the longer kilns are being installed around plants that are employing the wet process. As a result of long and painstaking development work, rotary kilns have been advanced to a point where the wet mixtures are fed directly to the kiln. The original rotary kilns were used exclusively as part of the dry process, and for many years did not seem adaptable to use in the wet plant.

The cement mixture is introduced at the high end of the kiln, while the oil, gas or pulverized coal used as fuel enters at the lower end. The kiln in turning over slowly, gradually works the mixture towards the lower end, at which point it changes to the condition of what is termed clinker, a mass of hard semi-vitrified balls about the size of marbles which, when cool, are much harder than the limestone which entered into their composition.

The following objects in the order of their occurrence are accomplished in the kiln: First, the evaporation of the water; second, the dissociation of carbonates of lime and of magnesia; third, the expulsion of the alkalies; fourth, the oxidation of ferrous to ferric oxides; fifth, the combination of lime and magnesia with silica, alumina and ferric oxide to form the silicates, aluminates and ferrites which make up the constitution of Portland cement. The kiln gases, fuel ash and kiln lining all have an effect on the



Flow of Material Through a Portland Cement Mill in Michigan

final product by the addition of clayey constituents such as silica, alumina and iron oxides which very slightly reduce the proportion of lime and magnesia in the finished product.

The inner surfaces of the kilns are lined with heat resisting materials in the form of bricks. These bricks are composed chiefly of alumina. Other substances, such as dolomite and magnesite compounds, bauxite brick and cement clinker have been employed and are still in use. This lining is from 4 to 6 inches at the upper end and from 9 to 12 inches at the lower end, which is the hotter. The lining bricks are held in place by heavy angle iron which encircles the inside of each end of the kiln.

The hood at the lower end of the kiln is mounted ordinarily on a carriage which compensates for expansion of the heated metal of the kiln. Holes are provided in the brick walls of the hood for the breaking up of clinker with rods, for making repairs and for making observations when the kiln is in operation. Clinker is drawn off at the lower part of the hood.

At the time the materials are introduced into the kiln, either by screw conveyor or slurry pumps, they are subjected to a temperature of about 1000 degrees Fahrenheit. By the time it arrives at the end of the kiln it is in a temperature of 2500 to 3000 degrees Fahrenheit, one of the greatest industrial heats employed. It requires about 3 hours time for a given quantity of material to pass through the entire length of the kiln.

Various fuels are used in the calcining process. The chief of these today is coal, and it is used in prodigious quantities. Every barrel of cement produced (376 lbs.) requires 200 pounds of pulverized coal or its equivalent. In other words, it takes 8/15 of the weight of the finished cement in coal to produce that cement. Of the 200 pounds of coal required in the preparation of 376 pounds of cement, 80 pounds are used in the kiln, 100 pounds for mill operation and 20 pounds for quarry operation. Of the 80 pounds of coal used in the kiln, 30 pounds or 37½ per cent are utilized for actual chemical work, 20 pounds or 25 per cent are carried out in heat by the discharged clinker, and 30 pounds or 37½ per cent are lost in radiation or in gases that go out of the kiln. In many places a considerable amount of this waste heat is made to do useful work. In one plant it is used to produce sufficient electricity to operate the entire mill. Waste clinker heat is used in other cases to heat the air coming into the kiln.

Bituminous coals only are used in firing rotary kilns and these should be what are known as gas coals. The reason for this last is that this type of fuel is quick to ignite, and quick ignition is an essential quality for rotary kiln work where the coal is blown into the kiln after it has been finely pulverized. Anthracite coals are not suitable, at least by themselves; for, although they produce great heats, they do not burn properly under rotary kiln feeding conditions.

The constitution of the ash resulting from the burning of kiln coal is an important factor in the selection of fuel for firing, for in rotary kiln operation the ash of the fuel enters into the composition of the mix. Analyses made of samples of coal ash from various parts of the country show great diversities of composition, silica ranging from 25 to 50 per cent, alumina and iron oxide from 23 to 55 per cent, lime from 3½ to 13¾ per cent, magnesia from nothing to 1¾ per cent and sulphur trioxide from nothing to over 7 per cent. With a properly understood and well controlled mix these coal ashes may be made to act as useful correctives of the mix instead of as unruly disturbers. In general, as seen from the foregoing analyses, the tendency of coal ash is to increase the clayey component. It has, too, the effect of acting as a flux for clayey ingredients that are too high in silica.

When coal intended for kiln firing is to be prepared for use it is sent first to the dryer or to the crusher, depending upon its state of fineness. When it is in the form of slack it is dried immediately in that condition, when in the form of lump or mine run it is passed to crushing rolls which reduce it to less than ½ inch. It then goes ahead to the dryer.

It is necessary to dry kiln coal because it may contain as it comes from the mines at certain seasons of the year as high as 15 per cent of water, though it ordinarily averages around 6

per cent. This water prevents the securing of good results in the grinding process.

The rotary dryer is utilized for drying coal as well as the other materials used in Portland cement manufacture, with a certain difference in procedure necessitated by the fact that coal, being itself combustible, cannot be treated by allowing the drying gases containing products of combustion to pass over it. A double cylinder dryer is used, the products of combustion traveling through the center and held away from the coal.

After the coal has been dried it is pulverized in mills of the several types used for pulverizing the raw cement mix. The general rule is that the poorer the grade of the coal the greater is the necessity for pulverizing it very finely. The general practice is to pulverize it to a degree where 85 per cent will pass a 200 mesh sieve. The finishing work of coal pulverization is sometimes done in tube mills.

In addition to the plants using coal for kiln firing there are also those which employ oil, natural gas and producer gas. None of these appears to be as economical as coal and any one of them is used chiefly where a good gas coal is not available. Good results are obtained by their use, but for all around general serviceability, coal seems to lead.

All these fuels are introduced as above described at the lower end of the kiln, the mix traveling toward it. Combustion takes place with greatest effect in a section of the kiln some 10 feet back from the firing end. This section is usually of greater diameter than the rest of the kiln. By the time the mix arrives at this part of the kiln it is in a temperature of 2500 to 3000 degrees Fahrenheit. It requires about 3 hours time for a given small quantity of material to pass through the entire length of the kiln.

When the mix reaches the end of the kiln it is in a white hot condition and in the form of what is termed "clinker," as described above. This clinker is dropped out at the end of the kiln, after which it may be handled in a number of ways. It may be picked up and carried by pan conveyors under a continuous spray of water and later passed through a pair of rolls; it may be carried by an elevator to a tower cooler or dropped to a rotary cooler. The disadvantage of the pan conveyor method is that it is conducted entirely in the open and does not utilize any of the heat of the clinker, which is taken up and put to work by the tower and the rotary coolers.

The tower cooler differs from the rotary in that it is a vertical stationary structure, while the rotary is mounted slightly off the horizontal and rotates on its approximately horizontal axis. The tower cooler receives the clinker from the kiln by elevator. As the clinker falls into the buckets of the elevator it is sprayed with water and dumped into the cooler, in the center of which is a blast pipe through which a constant flow of fresh air is maintained by means of a fan, the air passing out of the cooler through holes in its shell. The shell has conical shields on the outside just above these openings. The heat of the clinker is absorbed in the vaporization of the water and is removed by the current of air which passes through the stream of clinker moving through the cooler between the two shields. The cooled clinker is drawn off by belt conveyor and carried to the clinker storage.

The rotary cooler is the reversal of a rotary drier and is adaptable to securing a large amount of the clinker heat. In at least one cement plant two rotary driers are used in series, thus constituting a two stage operation which results in the recovery of a great deal of heat.

From the coolers the clinker goes to clinker storage. While in the form of clinker, a semi-vitrified substance, the cement resists the deterioration to which it is subject when pulverized into the finished product. Hence mills which have rather limited facilities for the storage of the finished product carry a considerable amount of clinker in storage and thus enjoy the advantage of a readily available supply of material that does not require much processing and also the advantage of a flexibility in the operation of the finishing and producing departments.

The next step in the production of a finished cement is the grinding of the clinker. This task is quite a difficult one, for the material is very

hard and strongly resists the action of the various mills employed in the process. Otherwise the work is much the same as the pulverizing of the raw materials that is done early in the process. There is, of course, a difference in the quantities of material to be treated. For every 376 pound barrel of cement produced 600 pounds of raw material are used. This 600 pounds is reduced in the calcining process to slightly under 400 pounds, the quantity of clinker that must be pulverized to get a barrel of cement.

The difficulty of clinker grinding increases with the percentage of lime in the clinker and with the length of time that the mix has been burned. The constant demand for finer and finer cements also imposes an added burden on the grinding department.

At the time that the clinker is ground, the retarder is also added. This retarder is gypsum (calcium sulphate, $CaSO_4$) and its function is to hold back or retard the set of the Portland cement when used in making concrete. It also adds slightly to the tensile strength of the cement. Gypsum is added in quantities up to 3 per cent as crude gypsum, calcined plaster, or dead burnt plaster. The active retarding agent is the sulphur trioxide present in the gypsum. As calcined and dead burnt plasters contain a greater amount of this than does the crude gypsum, they exercise, weight for weight, a greater retarding effect. However, crude gypsum costs much less than the treated products and is therefore used in much greater quantities than these.

The adding of the retarder is usually done right before the clinker goes to the first mill in the clinker grinding department. Gypsum rock is used for this purpose in ½-inch size. When plasters are used instead of raw rock they are added after the clinker has been ground. Obviously there is in the method of utilizing the raw rock, the advantage of a very thorough intermixing of the cement and gypsum.

As before mentioned the grinding mills used in the grinding department are of much the same order as the equipment used in grinding the raw stock for the cement mix. The clinker is ground to sufficient fineness to allow at least 78 per cent to pass a 200 mesh sieve.

After the clinker has been ground to the requisite fineness, the cement resulting is conveyed to the stock house where it is spouted or carried by conveyor into bins. When the cement arrives at this point it is usually tested, each bin being sampled. The samples are put through the routine physical tests and, when necessity arises, analyses are made. Inherent defects in the cement are quickly detected.

Portland cement is packed in bags weighing 94 pounds, four of these bags making a barrel of 376 pounds. The bags are of the valve type and are filled through a flap in the bottom by means of highly developed packing machinery. Portland cement is always furnished in a tied bag, the tying being done before the bag is filled. This represents a great saving. Not many years ago the filling of cloth sacks with Portland cement was a slow, back-breaking operation. Sacks were filled with shovels, weighed on a scale and tied by hand. A crew of four men working at full speed could not fill over 1600 sacks a day. By the method now in use that same crew of four men can fill and load 8,000 sacks in a day. Loading is done by moving belts which carry the sacks from the packer out to a freight car.

Earlier in this article we spoke of the manufacture of Portland cement by the use of slag and limestone, as a method different from either the wet or dry processes commonly in use around the cement mills of this country. A brief description of this process may be in order.

There are in vogue at different plants, three methods of preparing the mixture. The slag is granulated, dried and ground, while the limestone is dried and ground separately. Both materials are mixed in correct quantities in tube mills, pulverized and mixed, and the product is fed to rotary kilns. Another way is one in which the slag is granulated, dried and mixed with a little less than the proper amount of limestone as calculated, which limestone has been pulverized, dried and powdered. From 2 to 6 per cent of powdered slack lime is added to correct the composition. Mixing and fine reduction is then done in ball and tube mills. About 8 per cent of water is added to form

a slurry. This slurry is made into bricks which are dried and burned in a dome or chamber kiln. Still another method is one in which the slag is granulated and, while still wet, mixed with the proper amounts of crushed limestone. The mixture then goes through a rotary calciner, which is heated by waste kiln gases. The temperature of this device is not only sufficient to dry the mixture but partly to powder it and to reduce most of the limestone to quick lime. The mixture is then finely reduced and fed to rotary kilns.

By the term granulation of the slag as used above, must be understood the breaking up into small porous particles of the molten slag by bringing it into contact with cold water. This granular slag is much more easily pulverized than a slowly cooled slag. The only disadvantage is that the product contains 20 to 40 per cent of water, which must be driven off before the granulated slag goes in the grinding machinery. The granulation is accomplished at the steel mills by letting a stream of molten slag from the furnaces run off into a sheet iron trough, along which flows a small stream of water sufficient in amount to give complete slag granulation without excessive water absorption.

The grinding of the slag is still an expensive part of the process as compared with the grinding of limestones, clay or shale, and only the tube mill can properly reduce this material to the necessary fineness. It is reduced to 50 mesh without great difficulty but past that the grinding of slag gives much trouble.

There are certain undoubted advantages connected with the production of Portland cement by the slag-limestone process. The first of these is that slag, being a waste product, is obtained much more cheaply than the raw materials can be secured for the other processes. Then, too, lime occurs in the slag as an oxide and not as a carbonate and, therefore, requires less heat to accomplish calcination, since the amount of heat required to drive off the carbon dioxide from an equivalent mass of limestone is saved.

At a number of times, attempts have been made to manufacture Portland cement by blast furnace rather than kiln methods. The Hurry & Seaman patents call for mixing raw materials without grinding and burning the mixture to a state of complete fusion. The raw materials are mixed with carbonaceous fuel, tuyers supplying combustion by supplying a blast of air. The materials are melted and the cement is drawn off in a molten state, cooled and pulverized. The method did not prove successful; the cement was very slow setting, and the iron oxides in the mix were reduced and appeared as particles of metallic iron in the product.

A few words on one of the most important features of cement mill operation, that of power.

The average mill employes slightly under 1 h. p. for each barrel of cement produced daily. This power is used chiefly in the grinding of the raw materials and grinding the clinker. Coal grinding and the operation of the rotary kilns, coolers, conveyors, dryers, packers, etc., are less important consumers of power.

Most cement mills develop their own power and do this chiefly from coal. Sometimes the steam power resulting from the coal is used directly for the operation of the plant; sometimes it is used to generate electrical current from which the plant is operated. In a few cases large plants are being operated by gas engines. These cases, however, are very few, and the rapidly increasing use of gas engines as power sources has not yet struck the Portland cement industry.

Talc and Soapstone.

The production of talc and soapstone in 1921 showed a great decline as compared with that in 1920. The quantity sold was the smallest since 1908, and was about 40 per cent less than the average for the five preceding years, according to Edward Sampson, of the United States Geological Survey, Department of the Interior.

The total quantity of talc and soapstone sold in 1921 was 126,000 tons, valued at $1,821,000, as compared with 211,000 tons valued at $3,035,000, in 1920. This represents a decrease of 40 per cent in both quantity and value. Vermont which, since 1917, has been the largest producer, maintained its position by producing 38 per cent of the total quantity. New York produced 33 per cent of the quantity sold, but for the first time took second place in the value of its product. Virginia, which produced 14 per cent of the total, ranked next to New York in quantity, but for the first time led in the value of its output, owing to the fact that the soapstone industry in that state was not nearly so much affected as the ground talc industry, on which the other principal producing states depend.

The production and value by states was as follows: Vermont, 48,648 tons, $438,534; New York, 41,937 tons, $530,154; Virginia, 17,721 tons, $601,878; California, 8,233 tons, $128,188; Pennsylvania and New Jersey, 7.205 tons, $76,912; North Carolina. 731 tons, $17,048; Georgia, Maryland and Massachusetts, 1,959 tons, $28,737.

The quantity of ground talc sold by producers in 1921 was 106,900 tons, valued at $1,181,000, as compared with 178,500 tons, valued at $2,143,000, in 1920. A canvass of the producers made to determine the quantity of talc consumed in 1921 by different industries shows that the paper industry used 38 per cent of the total and that the average value was about $10.60 a ton. Most of the supply was obtained from Vermont and New York. The paint industry, which requires a high grade of talc, used 23 per cent of the total. Nearly all the supply was obtained from New York, and the average value was about $14.10 a ton. The roofing industry consumed 18 per cent of the total and drew its supply almost entirely from Vermont. The requirements for talc used in this industry are not exacting, as is shown by the average value, which was only $8 a ton. The rubber industry used a large quantity of talc for filler and in 1921 consumed 9½ per cent of the total. Vermont furnished most of the supply, which had an average of $9.50 a ton. The textile industry used about 4 per cent as a filler for cotton cloth. The average value was about $9.40 a ton. Only 2½ per cent of the domestic output was used for toilet powder, the demand for talc for that use having been supplied largely by imported material. California supplied most of the demand for domestic talc for this purpose, and the average value was $18.60 a ton.

Feldspar.

Feldspar sold by producers in the United States, 1916-1921.

Year.	Short tons.	Value. At price for crude spar.	Value. As sold (crude and ground).
1916	132,681	$404,689	$702,278
1917	141,924	474,767	728,838
1918	99,120	429,989	674,346
1919	71,054	347,992	585,200
1920	151,817	851,123	1,508,990
1921	102,889	617,652	819,319

Feldspar produced and sold in Canada, 1916-1921.[1]

Year.	Short tons.	Value.
1916	19,488	$71,407
1917	11,493	54,555
1918	18,782	112,728
1919	14,679	86,231
1920	37,873	280,895
1921	30,540	223,000

1. Report on mineral production of Canada, Canada Dept. Mines.

The United States imports nearly the whole of the Canadian production of feldspar and none from other countries. Imports and exports are not specifically shown by the Bureau of Foreign and Domestic Commerce.

Lime and Its Method of Production

Lime is defined as an alkaline earth consisting of the oxide of calcium, artificially secured by the calcination or burning of limestone in one or another of its forms. As an alkaline earth it falls into that class of substances whose properties are between those of the earths proper and the true alkalies, by which are meant the hydroxides of potassium, sodium, lithium and ammonium.

Limestones from which limes are secured are combinations of calcium, carbon and oxygen, the union of these three elements giving what is known as calcium carbonate ($CaCO_3$). The relationship existing between limestone and lime is indicated by the formula:

$$CaCO_3 + \text{heat} = CaO + CO_2$$

In other words limestone ($CaCO_3$) is lime (CaO) with carbon dioxide (CO_2) added to it. An ideal, pure limestone becomes dissociated at about 1,650 degrees Fahrenheit. Another substance, magnesium carbonate ($MgCO_3$), is frequently associated with and is similar in many points to calcium carbonate.

Limestones result chiefly from the deposition on ancient ocean beds of the calcareous remains of marine organisms, or of the throwing out of solution of the materials held in the waters of these oceans. The organic origin of the limestone can be clearly seen in many cases from fossil remains. In other places where limestones are formed from organic accumulations, there are no fossil indications to point to this origin, for the area in which the deposit is found may have gone through a number of natural processes which ground the material into a fine state. In addition, also, to the limestone deposits of organic origin, there are deposits which result from the evaporation of former oceans of which the only residue is the limestone.

Limestones as found in nature contain many impurities; chief among these are iron and aluminum oxides, silica, sulphur and alkalies. When iron is present in limestone it occurs commonly as an oxide or as a sulphide and in some cases as a carbonate or silicate. Silica and alumina frequently are found in combination in clays associated with limestone in its natural state. This material, while used to advantage in Portland cement industry, does not find such a place in the lime industry. Silica alone frequently occurs with limestone in the form of hornblende, mica or other associated minerals. Silica also occurs quite commonly in limestone as pockets or beds of flint or chert. Limestone sometimes contains alkalies, such as soda and potash, although these substances are present in small amounts and then only in limestone of loose texture. Sulphide occurs with limestone as a lime sulphate or in combination with iron as in pyrites.

Limestones that contain considerable sand are known as arenaceous; those which contain clay are known as argillaceous. Limestones containing both clay and sand are termed argillo-arenaceous.

Limestones vary considerably in hardness, texture and compactness. To the same group of minerals as limestone, belong the marls and chalks, the softest members of the family. From the condition of marl, the limestones vary in hardness through an infinite number of phases, occurring in their hardest form as marble, a metamorphosed and recrystallized limestone. The texture varies from that of the very coarse chalks to that of the marbles.

As stated above, limestones in some sections frequently contain in conjunction with the calcium carbonate, a greater or less amount of magnesium carbonate. When the magnesium content of the material is as high as 40 per cent the substance is called dolomite. Calcium carbonate is also known as calcite. Dolomite is a harder material than calcite and produces what is termed a "high magnesium lime," a material that is more suitable for many purposes than "high calcium lime" which is produced from calcite. Another associated mineral which contains a still higher proportion of magnesium is magnesite, the least common of the three, which occurs in smaller quantities and in fewer

places than either the calcite or the dolomite.

The quality of any given lime is the direct result of the character of the stone from which it was produced, and the operating methods employed. Of the many limestones found in nature, only those may be used for lime burning from which a marketable lime can be produced. The limestone must be of sufficient lime content to produce lime that will meet the demands of the trade. Impurities appear in lime in a much more marked way than they do in limestone. One reason for this is that about half the weight of the stone goes off as carbon dioxide, leaving the lime content relatively the same as it was in the limestone, but doubling the proportion of every other constituent. If a margin of only 5 per cent is allowed by the trade for impurities in the finished lime, that lime will have to be burned from a stone that contains only 2½ per cent of impurities and 97½ per cent of lime producing material.

Lime intended for certain uses may contain higher amounts of impurities. Lime, for example, that is to be used for agricultural purposes is not greatly hurt by the presence of a moderate amount of silica, iron oxide and alumina. The principal effect of the presence of iron in lime is to color the lime yellow or red and, if present in considerable amounts to increase the strength and hardness of the lime. The impurities act as dilutants. A small proportion of impurities is believed actually to improve the quality of lime for building purposes. Small amounts of silica in the lime tend to increase plasticity, sand carrying capacity and yield, without any effect on the hardness or strength. Alumina improves the color of lime and its presence in quite large amounts is desirable. Kaolin has about the same result as silica or iron. Gypsum in lime, even in very small amounts, is harmful.

Aside from the chemical properties of limestone there are the physical properties to consider, as influencing the suitability of the stone for burning. These physical properties show more in the process than they do in the finished product; that is to say, any kind of limestone of correct chemical constitution is suitable for the making of a good lime, but the process of making this lime will not in all cases be the same. Dense stone of fine grain burns more quickly and at a lower temperature than a stone which is porous. The production of lump lime, when coarse crystalline stones are being calcined, is likely to be considerably reduced because of the tendency of these stones, particularly when very pure, to fall to pieces in the kiln. Porous stones, possibly as a result of the rapid expulsion of water from the pores, behave in the same way.

The water content of all limes is of importance. This water must be evaporated with the expenditure of heat. Not only must the free water be so driven off, but also the water in chemical combination with the impurities in the stone. The more water in the stone the longer it must remain in the kiln and the more expensive must the operation be.

Quarrying methods employed for the securing of limestone for burning to lime do not differ radically from those in force at other limestone operations and which are described in this book under the heading of "Crushed Stone." Open face methods mainly are practiced in the lime as in the crushed stone industry. But the proportion of underground excavating operations is higher in the lime than in the crushed stone industry, for limestone intended for burning must be more carefully selected than limestone that is to be used for concrete aggregate. This last means that the excavating operation must follow more closely the run of the more desirable materials. Some lime manufacturers have gone to great expense to develop mining methods for the production of high grade stone. An example of this, though it cannot be considered in the light of an average case, is furnished by the stope mine of the American Lime and Stone Company at Bellefonte, Pa. Here a big task was undertaken to place at the company's disposal a more readily available supply of high grade limestone for the manufacture of the fine product that the Bellefonte plant turns out. The mine makes it possible to secure stone from a very fine stratum which is tilted at 52 degrees to the horizontal and for this reason

presents a very difficult quarrying problem. Because of the fact that the work is entirely in one seam of good stone and because no interference with beds of inferior stone will take place, it is possible to do all loading mechanically.

Mechanical loading is not practiced to as great a degree in quarries producing kiln stone as it is in ordinary limestone operations, this because of the obvious necessity for securing more carefully selected stone. In cases where it is necessary to quarry an amount of "bad" stone along with the good, great care must be exercised to insure the loading of nothing but stone that will make good lime. Ordinarily the appearance of the limestone clearly indicates its character to the loader and he will take care, particularly if the lime is for finishing purposes, to load only the proper material. Where the character of the stone is not so easily determined by its appearance, loading is a more difficult work and more experienced men must be employed at it if the operator is to get a good quality of lime.

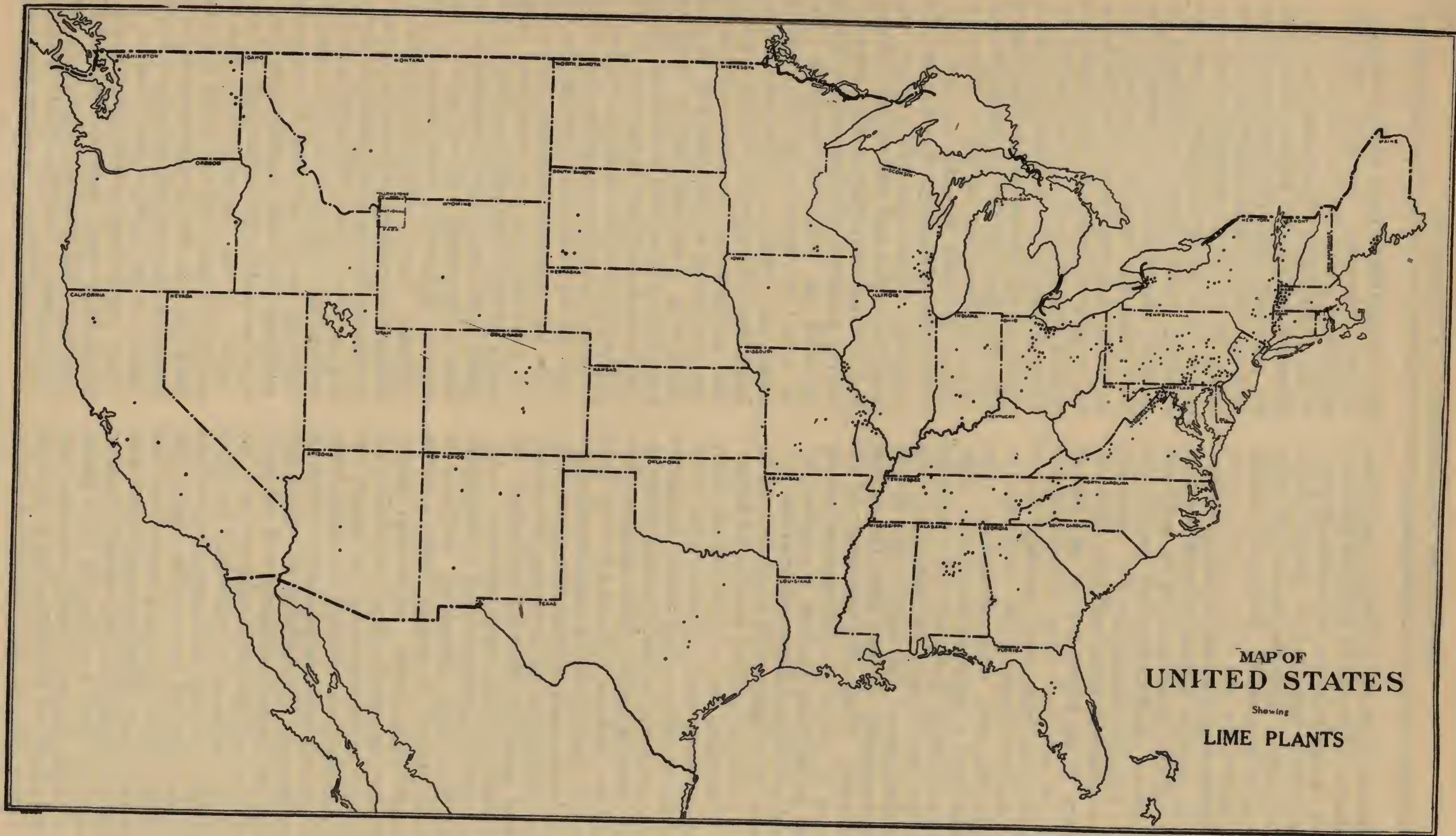
The methods of conveying from quarry or mine to plant are as diversified as those around any limestone operation and practice does not differ greatly or, in fact, at all. Provision, however, is made at lime plants turning out a number of other products such as ballast, flux, etc., for routing in their respective directions stone of varying character, intended for different purposes.

It is the custom to use in the vertical kilns most commonly installed in lime plants anything from a "one-man" stone down to 4 inch stone. Where the rotary kiln is used for calcining it is necessary to crush the stone first, as will be described later in discussing this particular piece of equipment. The stones of "one-man" size and under are brought to the level of the vertical kiln tops by any one of the number of conveying methods in force at lime stone quarries and are there unloaded for the charging of the kilns. This charging operation will be described below in connection with the description of the various types of vertical kilns used in the lime plants of this country. Taking up the consideration of the kilns used for lime production it will be well to consider the various limestones used, with particular reference to their burning qualities.

An absolutely pure limestone contains by weight, 56 parts of lime and 44 parts of carbon dioxide. These figures, which are theoretical, computed from the chemical formula, $CaCO_3$, are never realized in practice although they serve to indicate in general the number of actions that take place in the kiln. For example, to show that, calculated on the basis of a pure material, the limestone would lose 44 per cent in weight by burning to lime, we can say that a short ton of limestone charged into a kiln would result in the production of only 1,120 pounds of lime. There is also a decrease in bulk.

The above figure is based upon the burning of an absolutely pure and uniform limestone containing nothing but calcium carbonate. Unfortunately, the producer of lime cannot figure on such an ideal raw material and in actual operation must deal with a limestone which, while containing large amounts of calcium carbonate, is also associated with other substances some of which cannot justly be termed impurities, since with proper handling they add to the lime certain qualities that are desirable in a number of the applications of the finished product.

Limes, and consequently the materials from which they are made, fall into two general classes. There is the high calcium group and the magnesia group. Included in the first are limes that are high in calcium and with a magnesia content up to 5 per cent. Above this point of magnesia content, the material exhibits a change in characteristics and must consequently be considered as forming another class. This class, which instead of 5 per cent usually contains as much as 30 per cent of magnesia, produces lime that slacks more slowly and is cooler than the high calcium limes. In use, however, they are not so plastic and in spite of the fact that they yield a strong mortar are not so much in favor for a number of purposes. The high calcium limes are more plastic and slack more rapidly. Depending upon their content of impurities exclusive of magnesia, they are known as "rich" or "fat" limes, as distinguished from a lean or poor


MAP OF
UNITED STATES
Showing
LIME PLANTS

lime, which results when stone containing more than 5 per cent of impurities, exclusive of magnesia, is burned.

The impurities usually associated with the limestones from which are produced the basic or alkaline lime and magnesia are all acidic in character and readily combine with the basic materials to form salts. Aluminous impurities turn into aluminates; silicious impurities to silicates, and iron oxides into ferrites. In too great amounts these readily fusible salts have the effect upon heat application of closing up the pores and covering the lime particles, a condition which makes the slaking of the quick lime difficult and also injures the lime by making the material more compact and consequently decreasing its porosity.

In general the stones containing more magnesia are dissociated at lower temperatures than the stones with low magnesia content.

The theory of lime calcination presupposes three objects: First, the evaporation of water in the raw materials; second, the absorption of sufficient heat by the materials to cause chemical dissociation; and, third, the driving off of the carbon dioxide, after whose disappearance the carbonates assume the condition of oxides. Should one of these objects not be accomplished, the remaining one or two objects would also remain unaccomplished. As to the third object, the necessity for its accomplishment can be seen when it is stated that if the carbon dioxide is not removed from the presence of the stone in which dissociation has just taken place, the carbon dioxide will, supposing no increase in temperature to compensate for the pressure under which it is held, recombine with the lime and magnesia to form again the carbonate which had just been disassociated. This recarbonating action is guarded against by the use of methods designed to keep the gas pressure as low as possible. The practice of introduction jets or streams of water into the hot kiln for the purpose of reducing the pressure of carbon dioxide is resorted to quite commonly.

The kilns used around lime plants may be classed into vertical kilns and rotary kilns. Vertical kilns are divided into intermittent kilns and continuous kilns. Continuous kilns may be of the chamber type, separate feed type or mixed type.

The prototype of the pot kiln, the only surviving member of the intermittent kiln group, was simply a structure built of the larger blocks of the stone that was to be burned. A wood fire was started under this limestone structure and kept burning for a number of days, holding the stone at the right heat until it had become quite soft. At this point the fire was drawn and the lime removed after it had cooled. Fuel consumption was excessive and the plan of operation so crude in general that it did not survive the increase in demand for lime and gave way to the pot kiln which is still in use, though not to a great extent.

The pot kiln is also intermittent in that each burning of the kiln full of stone is a process that begins and ends with each batch of material of a size sufficient for the kiln to hold at one time. The principal difference between the pot kiln and the earlier type of intermittent kiln is that the structure of the pot kiln is permanent. It is made with a fire brick lining and with grates. Fire is controlled and burned lime removed through an arched opening in the bottom. The fuel consumption of this type of kiln is very high, because of the fact that the entire structure takes up and radiates great amounts of heat which are therefore not utilized in the process. It is difficult also to get uniformly burned material by pot kiln methods. Pot kilns more lately designed and operated on the continuous feed plan are proving satisfactory.

The chamber kiln, a continuous device, is used in a considerable degree in Europe. There known as the Hoffman type of kiln, it serves both the lime and Portland cement producers. This kiln consists of a number of chambers arranged around a central stack in the form of a circle or ellipse. Leading from each chamber are three flues running respectively to the central stack, and to the chamber preceding and the chamber following, each of these flues permitting opening and closing by a sheet iron slide. Each of the chambers is charged with stone and slack or fine coal is fed in

at the top of the chambers, one of which is fired. All of the flues in the kiln leading to the stack are closed except one which is left open, running from the chamber behind the one that has been fired. All the flues between chambers are open except the flue between the fire chamber and the one immediately behind it. As a consequence the hot gases from the fire chamber pass in turn through each of the other loaded chambers until they arrive at the chamber immediately behind the fire, from which they pass up the central stock. Waste heat consequently is fully utilized for preheating the chambers not yet fired. When the stone in the fire chamber is sufficiently burned it is allowed to cool and the chamber is cut off from the rest of the series by the closing of the flues. The chamber next to it is then fired and the empty chamber drawn and recharged. The flue connecting it with the chamber behind it is then opened, as is also the flue into the central stack. This makes the newly charged chamber the last member of series. This operation continues until all the chambers are burned.

Among the continuous kilns, a type that does not give entirely satisfactory service, is the vertical mixed feed kiln, which is as saving of fuel as the pot kiln is wasteful. The operation of the vertical kiln with mixed feed calls for charging with limestone and fuel in alternate layers. The process is continuous, the burned lime being drawn off at the bottom and new layers of fuel and limestone charged at the top. The great disadvantage of kilns of this type is that they yield a product that is discolored by its contact with the fuel and that the ashes of the fuel enter into the composition of the lime and clinker on the outside lumps, both of which actions impair the quality of the product and, during operation of the kiln, prevent even burning of the mass. On the other hand they are built more cheaply than the separate feed kilns which will be described next, use less fuel than the separate feed, and give a greater output in a given time. When there is a market for limes of the kind produced by the mixed feed process this kiln may be used to advantage, but for the making of the superior product that is being turned out today by American lime manufacturers, the mixed feed kiln is inadequate. Few mixed feed kilns are now in use in this country. The great bulk of American lime is made in separate feed, continuously operating, vertical kilns.

The separate feed vertical kiln differs essentially from the types described in that it is provided with separate fire places and applies the heat to the charged limestone without the meeting of the limestone and the fuel as such. Sometimes these heat sources or fire places are built on the outside of the kiln shell, which is cylindrical in shape, 35 to 50 feet in height and 5 to 8 feet in inside diameter. Fire places may also be provided in the wall of the kiln itself. These fire places are usually 2 to 4 in number. Limestone is introduced at the top by dumping from the quarry cars, skips or other conveyances used to carry the limestone to the tops of the kilns. This limestone fills the inside of the kiln, being drawn off at the bottom when properly calcinated. The fuels, burned in the fire places outside the kiln proper, exert their influence on the limestone not by direct contract but by the introduction into the kiln of the hot fuel gases. For this reason the separate feed kiln is not operated on as low a fuel cost as is the mixed feed kiln, for a certain amount of the heat is dissipated in the furnace and at points between the heat source and the limestone. In this method of operation, however, there is the advantage of an evenly burned product which is not discolored as is the lime from the mixed feed kiln. The product is in other ways more satisfactory for it is not associated with the fuel clinker and its chemical character is unchanged by the products of combustion. The firing of the kiln can also be more easily controlled, a desirable feature that it is not possible to add to the mixed feed kiln. This controlled firing has a direct influence on the evenness with which the product is burned. In general, a separate feed plan of operation gives 15 per cent more finished product than could be obtained from an equivalent quantity of raw stone calcined by the mixed feed process.

A vertical kiln with separate feed, as installed at American lime plants,

has a casing or outside shell of steel or masonry construction. The function of this casing is to act as a permanent structure and carry part of the weight of the kiln, to protect the lining from extensive thermal changes and to hold the heat which would otherwise be dissipated.

The steel casings may be round, as in the case of kilns with straight shaft, or conical to accommodate kilns with a shaft which flares out at the burning zone. There is also a casing of steel in combination with stone, brick or concrete.

An important part of the kiln is the lining or surfacing of refractory fire brick on the inside of the kiln. The purpose of this lining is to provide a surface which will, for a considerable time at least, resist the high temperature and the chemical action of the burning stone, and at the same time act as an insulator to hold heat in the kiln. The thickness of the lining is about the same throughout the length of the kiln, although it is sometimes increased at the hot parts. Linings suffer more from the chemical action of lime in the burning zone than they do from the heat, which is usually well within the limits of temperature that the material is able to withstand, for lime exercises to a greater or less degree a fluxing influence. The ravages done will depend upon the character of the lining and of the lime, and the temperatures employed. Linings must also be made of materials which, besides being able to withstand the heat and the chemical action, have also sufficient toughness to resist the abrasion to which they are subjected when quantities of lime rub against them in falling through the kiln.

The upper part of the kiln is known as the hopper. This section not only serves as a storage room for stone soon to be dropped into the hotter parts of the kiln, but also as a place where the stone is preheated by waste gases. Essentially the hopper is a wider space at the top of the kiln formed by the outward flare of the inner surface, and the thinning of the walls of the kiln at the top. While there is comparatively little heat expended at this point, the linings are frequently to the top of the hopper, but these linings are often of materials which have lower heat resisting qualities than the linings used in the shaft or portion of the kiln in which the actual burning takes place. Generally there is in the hopper of a kiln in operation a sufficient supply of stone to keep the kiln going 48 hours.

In the shaft of the kiln the actual burning of the lime takes place. As the stone passes down from the hopper, it gradually takes up greater heat until it enters the burning zone where calcination takes place. This burning zone is that section of the shaft level with and extending above the openings at the side of the shaft through which the heat used for calcining is introduced. After the limestone on its way through the shaft of the kiln passes this burning zone, it goes into what is known as the cooler, or section below the grates. Here the lime can come in contact with the outside air or with continuous steel walls cooled on the outside by air circulation. Lime is drawn off from this part of the kiln by one or another method, involving the use of dump cars, pan conveyors or endless chain conveyors.

There are two general methods in use for operating lime kilns. One is known as the "following" process and the other as the "sticking" process. Only enough lime is taken out at each drawing under either method to dump the incoming stone down the shaft so that the lower part of the mass of unburned stone is level with the point at which the heat is introduced. The "following" method consists merely in dumping from the lower part of the kiln sufficient lime to bring the unburned stone to grate level. The disadvantage of this method is that it leaves the chance of overburning a certain amount of lime that is left directly in front of the fires, due to the fact that the materials toward the edge of the kiln have already been pretty much burned because of the tendency of the heat to find its way up along the sides of the kiln.

This difficulty of overburning the lime towards the outside of the kiln and directly in front of the grates is obviated by employing the "sticking" process. When this method is practiced the kiln is chilled by letting the fire go down and by leaving the fire doors open for as long sometimes as

an hour before the time the kiln is to be drawn. As a result of this chilling the lining contracts and the fused compounds resulting from the lime's action on the lining solidify. These two actions of contraction and solidification together prevent the unburned stone from following. It sticks or hangs a considerable distance above the grates, none of it reaching down to grate level except a pillar of unburned stone in the center. The quick lime, of course, drops to a point just below grate level. When the drawing operation is concluded the pillar of unburned stone is knocked away, and the fires worked up to produce a high temperature.

When this method is followed the unburned stone drops down evenly to grate level. The arguments against the process is that it necessitates the cooling down of the kiln, and involves increased labor cost for the excess work incidental to "sticking," also the loss of production.

Whether the "following" or "sticking" method of operating kilns is in effect, the cooler or bottom compartment of the kiln is always full of lime. When this lime is drawn off from the cooler it creates a void that is filled up with calcined stone from the shaft, leaving room in the shaft for unburned stone, a supply of which in turn drops down from the hopper.

In some cases the cooler really serves the purpose that its description indicates; in others it does not, but appears merely to be a place where the calcination of a certain amount of the lime is completed by the heat resident in that lime and retained by the refractory linings on the inside surfaces of the cooler. Cooling cones built of heavy boiler plate and provided with jackets for the circulation of water are also common. The cold water circulates continuously in a downward direction, coming out hot at the bottom of the jacket. This means that lime is drawn either hot or cold. When it is drawn hot it is necessary to leave it remain for a time on the cooling floor at which time its heat is dissipated into the air.

As mentioned above, the vertical kilns are drawn by a number of methods, ranging from the use of barrows to well developed continuous drawing apparatus.

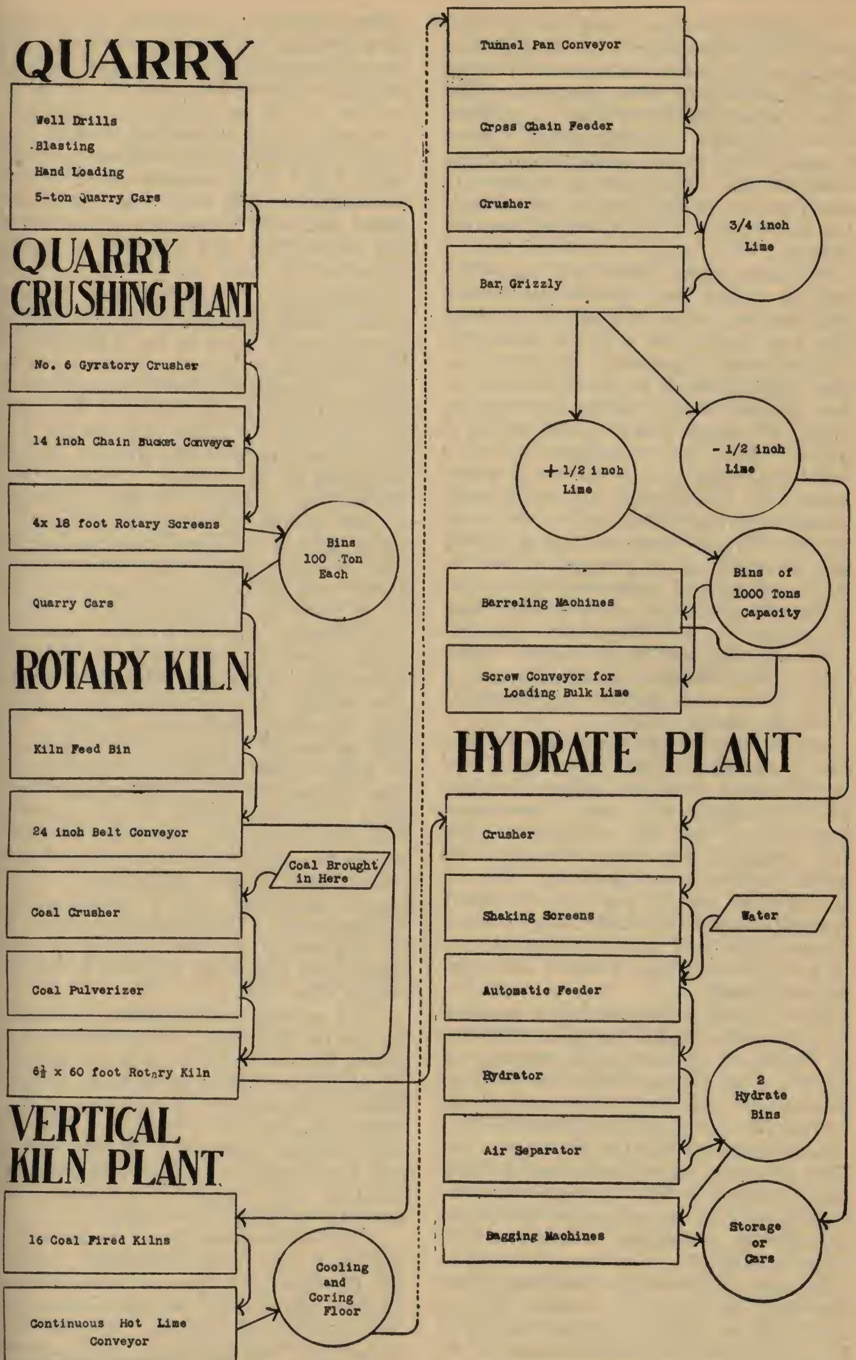
On the cooling floor such lime as requires it is "cored"; that is to say, each lump is sledged so as to separate the outer calcined portion from any unburned centers or cores that may exist. Underburned and overburned material is recognized by its appearance and is culled from piles of good material.

The handling of the lime after it has been on the cooling floor depends on the condition in which it is to be sold. If it is to be marketed as lump lime it is, when cool, conveyed by one of a number of ways to lump lime storage bins or to railroad cars. One method of conveying lump lime from the cooling floor that is considerably in vogue is by means of a tunnel conveyor running underneath the cooling floor, parallel with the piles of drawn lime.

When the lime is to be sold as a crushed product it is sent on to the crusher and, if necessary, to the pulverizer. Crushed lime intended for building purposes is seldom reduced to a size under ½ inch.

Limes are grouped or graded into a number of classes. There is run-of-kiln lime, or the product as it is drawn from the kiln, without sorting or additional treatment; and selected lump lime, a carefully burned material which contains no core, ashes or cinder. This class of material is secured by sorting the product of the kilns. There is also the ground or pulverized lime mentioned above.

In addition to these classes of limes, there is another which is produced by bringing about a further chemical action. This material, known as hydrated lime, is defined as a dry, flocculent powder that results from treating quick lime with enough water to satisfy chemically all the calcium and magnesium oxides in the lime. Before taking up a description of this product, however, we will describe a type of kiln that has, up to this time, been merely mentioned and which is used principally for burning lime for hydration. This type is the rotary kiln. Its product is quite desirable for the making of hydrated lime because it calcines stone that has been reduced to smaller sizes than can be handled in the stack kilns and yields a product that is more readily available for preparation for the hydrators.



Flow of Materials Through a Lime Plant in Tennessee

Possibly the best way to describe rotary kiln operation is to touch briefly upon the main features of a large plant employing this process, which was visited by the writer a number of months ago. In this plant is used a rotary kiln considerably larger than most in use. The plant is modern in every way; in fact, it is very likely the most modern plant in the country today.

At this plant stone of very fine quality is fed first to a large double roll crusher, which reduces it to small size and passes the product on to No. 7½ gyratory crushers. The material then goes through an intricate screening process which yields a great variety of stone sizes, none above 2 inches. Bins are arranged in such a way that any combination of stone sizes can be secured. A reclaiming tunnel running under bins draws stone of the various sizes to the grinding and calcining plant proper. After being recrushed, if necessary, this stone is passed to a tube mill, after which it is fed into a rotary kiln, 175 feet long and 75 feet in diameter. This kiln is fired by pulverized coal, somewhat after the manner employed in Portland cement kilns.

After burning the lime goes on to a rotary cooler 60 feet long and 6 feet in diameter, located below the kiln and arranged for the convenient transfer of the hot material. After the material has gone through the cooler it is sent to a hammer mill; or, if reduction at this point by the hammer mill is not necessary, the lime can bypass the mill and be sent to one of two ground lime bins of 320 tons capacity each.

The rotary kiln used for burning lime is quite similar to that employed in Portland cement mills, making in some cases, a respectable showing as to size and efficiency of operation. As a general rule, however, the use of a rotary kiln has not the footing in the lime industry that it has in the Portland cement mills. It has not the background of an extensive operating experience, and there is still much to learn about it.

Rotary kilns used for calcining lime are fired by coal, oil, natural gas or producer gas, although there seems to be a tendency, whenever possible, to substitute the use of directly burned coal in place of producer gas made from similar or lower grade coal. The use of natural gas, of course, is held strictly to those sections of the country in which an available supply is present. In this matter of fuel, the rotary kiln has an advantage over the stack kiln. It is economical as to fuel consumption and labor cost for operation and offers greater opportunity for controlling the burning temperatures.

Before the rotary kiln can become more widely used in the lime industry, practices will have to be standardized to a much greater extent than at present. Undoubtedly there are possibilities in this type of kiln that have not as yet come to light and which will only when some of the greater uncertainties as to proper practice are worked out. Right at the beginning of rotary kiln operation, there is disagreement among producers as to the size of stone that burns best. Practices vary all the way from the use of ⅝ inch to 2 inch material. Stone considerably smaller than ⅝ inch has given a very satisfactory product, but these small sizes are not fed as a regular thing. An argument that a leading producer advances against the regular use of fines, although they are to some extent used in his plant, is that a mass of stone containing fines as it turns over and over in the rotary kiln, will gradually work the fines towards the center of the mass and prevent their proper calcination, which means that they will come out as unburned cores. This would seem to be an argument for even sizing of material and certainly against overloading of the kiln.

Kiln speeds and charging rates will be more definitely established when there is available a greater amount of statistical information upon experience at a number of plants. A kiln driven too fast will result in improperly burned material. A kiln driven too slow results in the material becoming too highly heated and the starting of a fluxing action.

Kiln inclination is a matter that has not yet been definitely settled for the lime industry. There will, of course, always be certain differences in practice at various plants, but something approaching the cement manufacturers more or less general

practice of inclining the kilns at ½ inch a foot, will later be developed. The steeper the inclination the more slowly must the kiln be run, and vice versa.

A rotary kiln does not produce as much lime per unit quantity of stone charged as does a stack kiln. Just why this is so has not yet been determined, for the action which takes place in either case results in the same product, and the place in the rotary kiln where the difference in weight is established has not yet been determined.

The product of the rotary kiln is used for making hydrated lime which has been described as a dry flocculent powder resulting from the treatment of quick lime with sufficient water to satisfy the calcium and magnesium oxides in the lime. It is slaked lime with the slaking scientifically accomplished under the supervision of men trained to do this work as efficiently as possible. The promotion of the sale of hydrated lime is one way in which the manufacturers are meeting a condition that has long been detrimental to their business. This condition is the slaking of lime on construction jobs by men who are not trained or who will not take the care to do their work with some degree of precision, their mistakes creating many controversies in which the lime manufacturer was blamed for producing an inferior product.

The process of hydration involves three stages: First, the reduction of the lump quick lime to fairly small size; second, the thorough mixing with a sufficient quantity of water; third, the separation of unhydrated material and impurities.

The first commercial attempt at the production of hydrated lime was termed the Pierce process. Here, the lime was slaked to a wet paste which was later dried to expel all the moisture not required to satisfy chemically the calcium and magnesium oxides. This process made possible a good grade of hydrated lime, but costs were excessive and it was abandoned.

The next attempt was the Dodge process, in which the lime was ground to pass a 26 mesh sieve, after which it was mixed with just sufficient water to satisfy the lime chemically and produce a dried hydrate which was then sifted through a fine silk cloth.

Hydrated lime is produced at the present time by a number of processes, differing considerably in details of operation, but all producing an entirely satisfactory product. There are two general operating methods. Lime is produced continuously or in batches; that is to say, one process supposes the continuous charging and production of hydrate, and the other the production of this material in batches. The main features of some of the various continuous processes will be described first.

In one continuous process ground or cracked lime is fed into the top cylinder of a series containing six cylinders, and arranged one above the other in parallel rows. Water is also fed separately into the top cylinder, the amount of lime being controlled by a screw feed, and the quantity of water by a needle valve. Propulsion of the lime and water through the series of cylinders is accomplished by paddles mounted on a shaft extending through each cylinder, rotated by gears outside the cylinders. Both lime and water are thus carried from cylinder to cylinder, dropping from the end of one into the next, but each time reversing its direction, of course, since the cylinders are set parallel one above the other. When the material comes out of the lower or last cylinder it is thoroughly hydrated.

In another continuous hydrator the lime is distributed in even layers. Water is so applied as to come in contact with every particle of lime at the proper time, thus causing the mixing of a large mass with evenly distributed water. The mixing action utilizes a furrowing motion working against centrifugal force. Action can be accelerated, retarded, or otherwise controlled to suit conditions, according to the nature of the quick lime. Levels are so constructed as to permit the mass further advanced in the process of hydration to pass to the next lower level or stage, and retain the heavy unfinished particles for further hydration. Flow of material into this hydrator is controlled by an automatic weigher, which also governs the supply of water. Material is drawn off at the bottom as finished hydrate.

Still another continuous hydrating process employed a cylinder slightly

inclined from the horizontal, like a rotary kiln or cooler. Weighed amounts of lime are introduced at the open end, sufficient water is added and the cylinder revolved. Inside of the cylinder are a series of encircling rings which serve as dams to retard the flow of the lime to the lower end. Lighter hydrated particles rise and pass over the retarding rings while the heavier unhydrated particles are retarded until hydration is complete. Finished material is drawn off at the lower end which is enclosed with a tapering screen to separate the hydrated material from any unhydrated particles which may have gone through.

The single cylinder idea is utilized in another continuous hydrator, but here the cylinder is stationary and paddles on the shaft feed the lime forward by their revolutions. Water is added at the top of the cylinder. Hydration is accomplished as the material in its general movement forward is mixed with the water.

The batch hydration process calls for the feeding of a weighed quantity of ground lime from a hopper directly into a large horizontal pan, which is mounted so that it can be rotated around its axis. This pan contains a series of plows which mix the material in the pail. A calculated amount of water is added to the weighed lime. When the agitation caused by the plows is considered to have accomplished sufficient hydration, the hydrated material is dropped through an opening in the sides of the pan.

In all of these processes, excess water is driven off as steam and impurities later removed by screening or air separation, etc. Thus a purchaser of lime is guaranteed in a hydrated product, a material in the preparation of which guess work or rule-of-thumb methods have played no part.

After thorough hydration the material is, if necessary, pulverized and processed to eliminate dust and dirt, and is then passed on to finished hydrate storage bins or tanks.

Hydrated lime is put up by the manufacturer in a number of packages, all of which are weighed and packed automatically. Hydrate is put up in 100-pound cloth bags and 40-pound paper bags. A number of manufacturers put up 10-pound packages for garden and sanitary purposes, distributing these through grocery houses.

Lump lime is put up in 180-pound barrels of wood or steel. Plants often operate their own cooperage and steel barrel making shops. The steel barrels are made from 27 gauge sheet steel 26 inches high and 18 inches in diameter.

In addition to the lime that is used for building purposes the material has a great number of other uses. It is of great value in the agricultural field and has many chemical applications. The 1922 convention of the National Lime Association emphasized the advance that has been made by lime in the chemical field.

Lime is used in large quantities by glass manufacturers; whether high calcium or high magnesium limes are required depends upon a number of circumstances. Some glass manufacturers will not use a lime that contains as high as 3 per cent of magnesium while other manufacturers to accomplish equivalent results prefer dolomitic limes containing as high as 35 to 40 per cent magnesium. Limestone is sometimes used in place of lime, but batches of glass made of limestone can not be melted without the use of much more heat. Lime, too, contains no organic matter. Hydrated lime is less desirable in glass manufacture than quick lime.

High magnesium limes are used in the making of sulphate paper pulp. In the process of making sulphate there is produced magnesium bisulphate which is more stable than calcium bisulphate and produces more general liberation of sulphur dioxide in the cooking process, giving a more uniform pulp.

Lime to be satisfactory to the sulphate paper manufacturer, should also be free from iron and other metallic impurities. Air slaked lime should not be used as the moisture is likely to vary.

Quick lime is used in converting sodium carbonate into caustic acid and sodium sulphate into sodium sulphide. These two processes form a part of paper manufacture. The important thing about lime to be used for this purpose is that it have a high calcium oxide content. Metallic impur-

ities in the lime have no bad effect in this process, but are merely present as so much ballast. However, an excessive amount of silica very greatly reduces the active calcium oxide content. The formula for this causticizing process contains but 90 per cent active calcium oxide and not over 1¼ per cent magnesium oxide and 1½ per cent silica.

Lime and soda ash are used for water softening, sometimes on a very large scale as in central or public water softening plants. Water poluted to a high degree is made soft and safe to drink by the soda ash and lime process followed by mechanical filtration.

Lime is used in textile industries for two purposes. The more important of these and the one requiring the greater amount of lime is that which includes the lime boil, recausticizing of waste caustic liquors and the softening of water for dying. The second purpose calls for the use of small amounts of lime for such work as liming keirs, dyeing and the scouring of wool. Specifications of lime for textile industries rest very largely with the individual preference of the manufacturer, influenced by the old traditions of the industry, the light of technical knowledge and the active propaganda of large alkaline manufacturers.

The manufacture of calcium carbonate is accomplished by the heating of lime and coke to a high degree in an electric furnace, and a high calcium lime is required for this product, which is used largely as a source of acetylene gas. The purest high calcium limes obtainable are also required in sugar manufacture to remove impurities in the juices of the beet and cane. After the lime has done its work it is removed by the introduction of carbon dioxide which unites with the active calcium oxides to form a carbonate.

Soda ash manufacturing processes utilize ground high calcium lime to recover ammonia. Moist, select high calcium lime is used to free illuminating gas distilled from coal of carbon dioxide, sulphuric acid, etc. The lime is also used to remove ammonia.

Either magnesium or high calcium lime is used in the treatment of fats to bring about a liberation of glycerine. The treatment of fats with slaked lime also results in the forming of glycerine by combination of the lime with the organic acids. Lime soaps mixed with mineral oils produce lubricants which give very satisfactory service at high temperatures or with heavy machinery. Lime soaps also form the basis of most so-called active water proofing compounds, which are used to reduce the permeability of concretes and cement mortars.

Magnesium limes are used to make cold water paints which are mixtures of hydrated lime or lime carbonate with pigments and casein. This is the largest group of paints outside of that made by mixing with oils.

Tanneries utilize high calcium limes to soak hides and thus loosen hair so that it can be scraped off.

Wood alcohol, acetic acid and acetone derivation utilize in the manufacturing process high calcium lime. The wood alcohol is produced by redistilling with lime.

The Manufacture of Gypsum

Gypsum occurs in nature as rock gypsum, gypsite, selenite and satin spar. The most common of these forms is rock gypsum and most of the gypsum products in use are made from it. It is nearly always an opaque rock, composed of very minute crystals, the deposits being interbedded with sedimentary rocks. Pure gypsum, deposits of which are found in the central and western states, is white, but the stone as it occurs in nature generally contains impurities, and may be pink, blue, green, gray or brown, these colors either running evenly over the rock, or appearing as bands or mottling. One of the more valuable occurrences of gypsum rock is that known as alabaster. This variety is a highly consolidated material, very fine grained, white and slightly translucent. It is very suitable for sculpturing and carving.

Rock gypsum is found in many sections of the country, ranging from thin layers to deposits 60 feet or more thick and extending over many miles.

Gypsite is gypsum in any earthy form, a soft incoheren tmineral, formed by the evaporation of gypsiferous waters. The material occurs in forms as powdery as wood ashes to a form that is slightly consolidated, ranging between these extremes through a number of sandy and earthy phases. Gypsite is gray, mottled with white, buff, pink or red, depending upon the character and quantity of materials with which it is associated. These colors are carried largely by the clays and fine sands which are mixed in with the deposit. The largest known gypsite deposits cover only a few acres, and are seldom over 20 feet thick. It is mined chiefly in Kansas and Oklahoma.

Gypsum, gypsite and alabaster bear a relation to each other that is analogous to the relation between limestone, marl and marble.

Selenite occurs in distinct crystals or broad folia, some of the known crystals occurring, though rarely, in lengths of over 4 feet. Selenite splits easily into sheets. In its pure state it is colorless and transparent and has much the appearance of mica, for which it is often mistaken. Its outward appearance, however, is its only point of resemblence to mica, for it is not elastic.

Satin spar, a crystalline variety of gypsum that occurs in needle like fibres, is found in numerous veins or seams, usually less than 3 or 4 inches in thickness, either in massive gypsum deposits or close to these deposits in the wall rocks. The fibres are perpendicular to the walls of the vein. The deposits are the result of the evaporation of gypsiferous water, usually lying below the bed of gypsum. It is ordinarily white or pink in color.

Gypsum occurs in large deposits in many localities throughout the United States. The most important mining sections are in New York, Iowa, Michigan, Ohio and Texas. There are occurrences of gypsum in many other states where operations are carried out on a fairly extensive scale, and there are in a number of other places known deposits that have not yet been developed.

Gypsum is a hydrated sulphate of calcium, a material that is neither acidic nor basic because of the fact that the lime and the sulphuric acid are combined in exact equivalents. Pure gypsum runs 32.6 per cent lime, and 20.9 per cent water. A similar 46.5 per cent pure sulphuric anhydride material is anhydrite which is frequently found free in nature, associated with gypsum. Anhydrite has the same formula as that of deadburned gypsum. In other words, its chemical composition is the same except for the fact that it contains no water of crystallization. Anhydrite is turned to gypsum by the absorption of the two parts of water, a process which actually takes place in nature. Many beds of gypsum have undoubtedly been formed by the absorption of water by anhydrite.

About 80 per cent of all the gypsum produced is calcined, the other 20 per cent being sold in the raw state, either crushed or ground, especially for use in the manufacture of Portland cement or as a fertilizer. It is in demand with the cement manufacturers because it corrects the tendency of freshly made Portland

cement to set too quickly to permit of its being handled with convenience. The addition of gypsum up to as high as 3 per cent by mass of the cement, effectively retards the setting of the cement. The gypsum is added just before the final grinding, so that it can be thoroughly mixed. Calcined or raw gypsum produces the same effect, but the calcined material is not nearly so much in demand with the cement manufacturers as the raw gypsum, which accounts for about 80 per cent of all the material used for this purpose.

Gypsum as a fertilizer has come into considerable prominence. When used for this purpose it goes under the name of "land plaster." The reason for its success is the fact that it contains two necessary plant foods, calcium and sulphate which, because of the comparatively high solubility of the material, are quickly available.

A number of gypsum operations are conducted solely for the purpose of supplying the market for raw gypsum, and all producers of calcined gypsum have made at their plants provision for drawing off raw rock, crushed or ground, for the purposes that it serves so well.

As stated above, the variety from which most of the tonnage is secured, is massive or rock gypsum, which occurs ordinarily in beds several feet thick. Sometimes the flat lying bed is close to the surface and quarry methods are employed. The overburden is stripped, and the material blasted and loaded into quarry cars for hauling to the mills. In other places the quarrying operations are continued at the outcrop up to the point where the overburden becomes excessive, after which the quarrying methods are abandoned and the material is secured by mining. Adits are driven in the quarry face and follow the lay of the stratum. Gypsum deposits covered by a considerable overburden are also reached by vertical shafts from the foot of which tunnels are run, following the lay of the seam. The room and pillar system of mining is employed where flat lying seams are encountered, but where the gypsum beds dip strongly, a sloping shaft follows the lay of the seam with drifts running out from it, from which the rock is taken by stoping.

Main haulageways in flat lying beds run back to considerable distances. These haulageways are always at least as high as the thickness of the gypsum beds. Where the beds of gypsum are narrow these main thoroughfares of the mines are made high by cutting into the underlying rock. The working places of the main haulageways follow the height of the deposit.

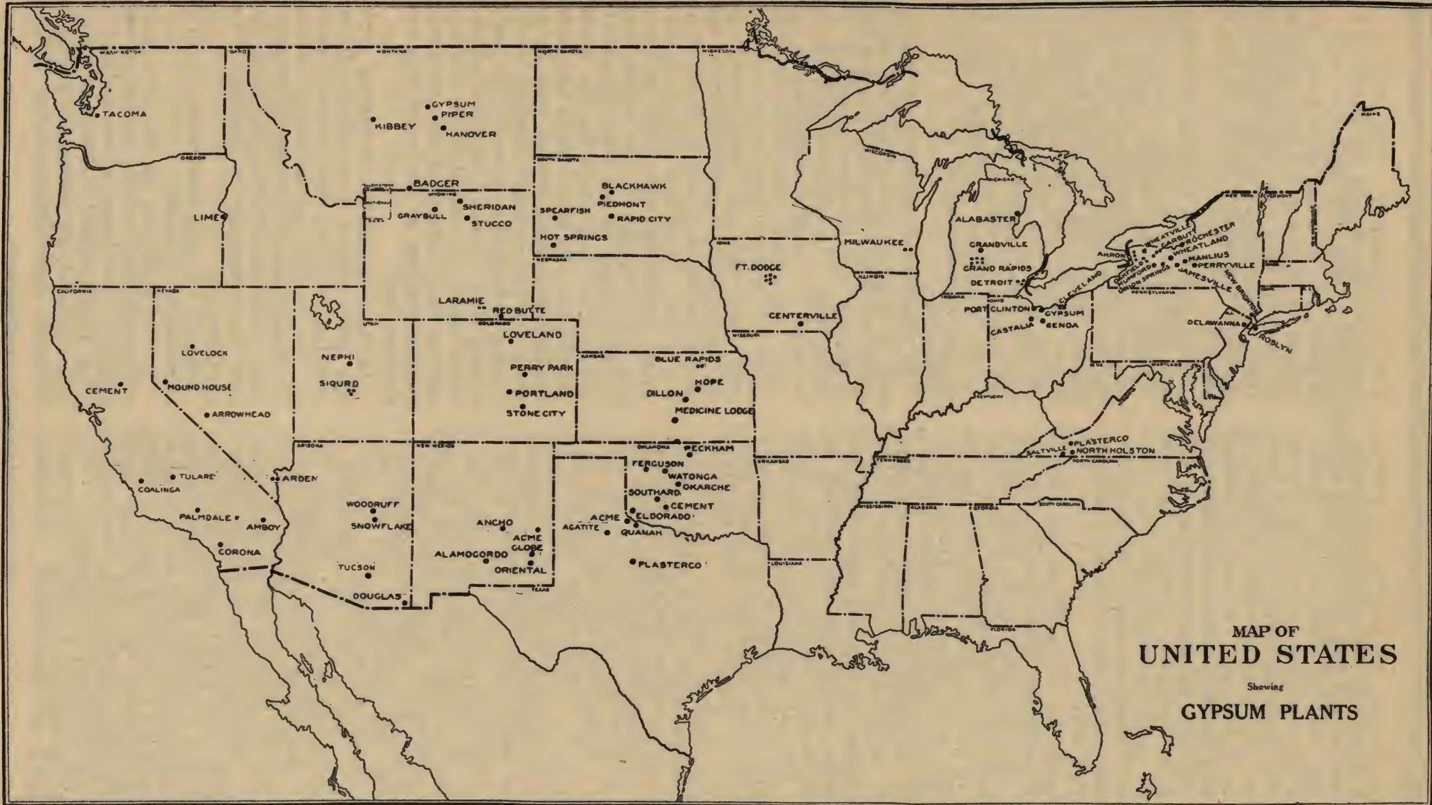
Rock gypsum is secured by blasting and loading into mine cars. Drill running is done while loaders are working at the face, loading by hand the stone brought down by a former blast. Shots are made at night and from these are secured sufficient broken stone for the next day's loading. Stones larger than one man size are broken by sledging or by the use of air hammers. Loaders and drill runners usually work on a contract agreement.

A number of methods of haulage are in vogue. Mules are in use in many workings, but they are gradually giving way to more improved motive power. In larger mines storage battery or trolley locomotives are used, sometimes both. In the last case, the trolley locomotive would be used along the main haulageway and the battery locomotive would be used in the tunnels running up to the working places. The battery locomotives would make up cars into trains on the main track, these trains later being brought to the adit entrance or the foot of the shaft by the trolley locomotive. In some cases both train haulage and handling of cars to and from the places are managed by this trolley locomotive, through the use of a long reel of heavy insulated electric cable which is mounted on the locomotive and connected to the trolley line, unwinding as the locomotive runs further back.

In many mines the matter of drainage offers quite a problem. In one working in Iowa, the hardest feature of the mining operation is to keep the mine drained for convenient operation. This mine is over 500 feet deep and the company is fighting water continuously.

Nearly all gypsum mines are now electrically lighted.

At the places in the western states where gypsite is used, instead of rock gypsum, the deposits are worked by open face method. The material is dug by hand, by power shovel or by scrapers, and hauled to the mill in



MAP OF
UNITED STATES
Showing
GYPSUM PLANTS

quarry cars. When it reaches the mill, the gypsite is dumped into storage bins and requires no further treatment before being sent to the kettles.

The rock gypsum is brought to the mill by any one of a number of conveyances. In some of the mines where the deposit is reached by vertical or sloping shaft, the contents of the mine cars are dumped into skips. These skips are hauled by cable to the tipple.

Quite a number of tippling methods are in vogue. In fact, practices at this part of the plant are as varied as at any other stone operation. In a number of cases air hoists or cable hoists are used to dump cars, sometimes operation is by gravity. In this last case end dumping cars are run on a rocking tipple, which drops forward and dumps the stone to a crusher.

Gyratory crushers are chiefly used for the first breaking operation, although many mines employ a jaw crusher first, and follow this by a gyratory. In some mills a small jaw crusher, a "cracker" is used for handling stone over the 1 1-2-inch size which is scalped out by the screen between the cracker and the primary crusher.

At about this part of the operation, some of the plants have installed magnetic separators for taking out "tramp" iron, which might, if not removed, work serious harm to the grinding machinery used later on in the process. This separator is usually installed on a belt running from the primary crushing equipment.

Provision is made at some mills for storing considerable amounts of crushed gypsum rock. This storage is either in large bins or silos, or in open stockpiles which are supplied from above by a belt conveyor, and from which stone is reclaimed by a tunnel belt conveyor running underneath. Sometimes the tunnel belt conveyor, reclaiming from the stock pile or the storage silos is made to discharge direct into a rotary dryer, the next piece of equipment in the process.

In the dryer is removed the most of the free water of the rock, acquired in the mine, together with what additional moisture it may have gained when in exposed positions such as stock piles. Temperatures sufficient to affect the water of crystallization are not employed at this part of the process. The operation of the dryer is continuous, material entering in the upper end and passing on towards the lower or firing end. The hot gases from the furnace are kept moving through the dryer by a large blower. The rock as it drops from the dryer, is picked up usually by a pan conveyor or a bucket elevator and brought to the pulverizer. The dry rock is pulverized in burr, emery, or roller mills. Sometimes a hammer mill is used in the process ahead of the mills mentioned above. The pulverized product of all this equipment is handled by chutes or blowers and passed on to bins from which the equipment used in the calcining process is fed.

At this part of the process, dust collectors are employed considerably. Screw conveyors are also used to a considerable extent as being efficient equipment for the handling of very fine material. These conveyors work in tightly closed steel troughs and they carry material with little loss and with considerable gain in cleanliness to the whole plant.

From the large bins containing pulverized gypsum are fed the calcining kettles, hollow cylinders of boiler plate with convex iron or steel bottoms having a diameter of 8 to 14 feet, and a height of 6 to 10 feet. These kettles, so called because of their shape and function, rest on masonry fire boxes and are surrounded by brick shells. The interior mechanism of a calcining kettle is simple. It consists of a curved cross arm to which are attached a number of stirring paddles that act as an agitator, keeping the gypsum continually in motion and making certain that all the material fed to the kettle is subjected to the heat necessary for proper calcination. The top of the kettle is covered with a sheet iron lid in which are the loading doors.

The fine material, whether it be gypsite or pulverized rock gypsum, is poured slowly into the kettle in which is maintained a heat of 212 degrees F. Very gradually this temperature is raised to 230 degrees F., and the water of crystallization held by the gypsum is driven off in the form of steam which, finding its way through the material, fluffs it up and gives the appearance of boiling. At approximately 240 degrees F., this apparent boiling stops, and the mass settles

down, being what is called "first settle" plaster. The processing of a kettle full of gypsum to "first settle" takes about an hour. If "first settle" is required, the material is drawn off at the bottom of the kettle. If, however, the batch going through is intended for use as "second settle" plaster the temperature is again raised and the boiling phenomonon begins again at about 270 degrees F. The second settling takes place at around 350 degrees F., and the material is drawn off. The kettles are emptied through gates at the bottoms. Material is passed to fireproof bins or to a floor for cooling.

As noted in the description of rock gypsum, that material when pure contains about 20.9 per cent water of crystallization held in chemical combination and consequently not affecting the appearance of the stone. This water of crystallization, however, can be driven off by heat and it is the departure of the water from the gypsum that causes the separate phenomona of first and second settling. As the steam from the heating of the water of crystallization rises, it tends to carry the powdered gypsum up with it, and imparts to the whole mass the appearance of boiling. The "first settle stucco" or "calcined gypsum" is gypsum from which a part of the water has been removed by heat. "Second settle stucco" is gypsum from which all the water of crystallization has been removed by heating.

The chemical reaction involved in the production of first settle stucco is:

$2(CaSO_4.2H_2O) + \text{heat} = 2CaSO_4.H_2O + 3H_2O.$

One way of expressing first settle stucco by chemical formula is $CaSO_4.\frac{1}{2}H_2O$ from which formula the material gets its name of "hemi-hydrate." The water content of first settle stucco is about 6.2 per cent, the reduction of which from 20.9 per cent changing the proportions of the lime and sulphuric anhydrid to 38.6 per cent and 55.2 per cent respectively.

The reaction involved in the production of second settle stucco is expressed by the equation:

$2CaSO_4.H_2O + \text{heat} = 2CaSO_4 + H_2O.$

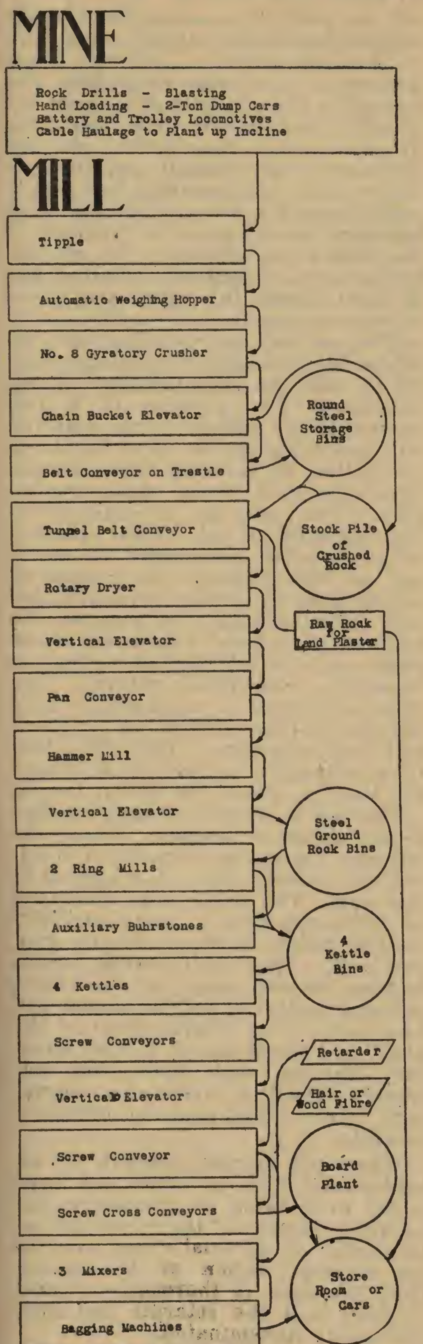
This substance is identical in chemical composition with the mineral anhydrite which occurs free in nature, but differs greatly from it in its chemical and physical properties. Second settle stucco, which is frequently called "soluble anhydrate," takes up water very readily, while natural anhydrite requires weeks before it can be made to combine with enough water to form satisfactory gypsum.

Second settle stucco sets much more rapidly than first settle stucco. In fact, so readily does the second kettle material take up water that a few minutes exposure to air suffices for it to absorb sufficient water to bring about a change into first kettle stucco.

Second settle stucco is made in considerable quantities, for immediate use at the mill in the various manufactures. Many attempts have been made to put this soluble anhydrite on the market, but it has always happened that by the time the material had reached the job, it has reverted largely to the condition of first settle material, making the additional expense of the second calcination unnecessary and wasteful. But, used in its proper place, soluble anyhydrite has many advantages over calcined gypsum. It requires less water to make it plastic and as a result the material, when set, is harder, stronger and denser.

Many gypsum mills have a continuous screw conveyor running along the floor parallel to the backs of the kettles. The calcined gypsum is spouted into the trough of this conveyor and brought to the foot of an elevator which brings it to the top of the mixing plant. Some gypsum mills which operate board and block plants have made arrangements whereby conveyors to the plants receive a direct kettle stream through one form of conveyor or another. At about this point also automatic weighing devices are installed in some cases to check u the exact amount of material going to the board and block plants. Occasionally these board and block plants are owned by outside concerns and the automatic weighers serve as reliable means of determining just what amount of material changes hands.

In a few plants, mostly of those erected more recently, the method of operation employs quite a different type of machinery. In these plants the method is more after the order of that used in the making of Portland cement, with calcination accomplished in rotary kilns instead of in kettles, and with the use of tube mills or Kent mills for fine grinding. In a number of plants using the kettle



Flow Sheet of a New York Gypsum Plant

method the tube mill is also employed, in some cases before, and in other cases after calcination.

In some of the very large and more modern plants calcination is completed in rotary kilns, but in other plants only part of the action takes place in kilns and the rest in brick lined calcining bins. When this latter method is employed the stone is fed to the rotary kilns in about 3-4-inch size and in its course through the length of the cylinder is partly calcined by hot gases, which eliminate most of the free water and some of the water of crystallization. To accomplish this it is necessary to raise the stone to temperatures of 400 to 600 degrees F. It takes about ten minutes for the entire operation, at the end of which time the stone is heated uniformly and is removed in a steaming condition and passed on to the brick lined calcining bins.

The construction of these bins is such that the gypsum is thoroughly ventilated during the process of calcination in the bin. No air from the outside is allowed in and the ventilating action is caused entirely by the heat resident in the material itself as it comes from the rotary kiln. This heat disseminates itself rapidly and completes the calcining process. In plants where this process is employed there are four such bins, each bin equal to the daily output of the plant. These four bins are necessary to insure continuous operation. At all times when calcination is going on in two bins, the third bin is being discharged and the fourth is being filled.

The pulverizing of plaster made by this process is done, of course, after calcination. A number of various types of fine grinding machinery are being used in various places.

In a number of large gypsum plants being erected at the present time, equipment more similar to that used in the manufacture of Portland cement than has heretofore been employed in the gypsum industry, is being installed.

The ideal composition of calcined gypsum or plaster of paris is represented by the formula $CaSO_4.\frac{1}{2}H_2O$, which calls for 93.8 per cent of calcium sulphate and 6.2 per cent of water. This water represents a residue of about one-fourth of the water

of crystallization present in the gypsum in its raw state.

After calcination and the latter grinding process the gypsum or stucco as it is called from this point of the process on, is raised to storage bins in the upper part of the section of the mill that is devoted to mixing. In some plants the mixing process is carried on in a separate structure, the stucco going over in a screw conveyor or other device serving the same purpose.

In the mixing department there are three working levels or floors, the highest being that at the top of the bins where the stucco is run in.

The more modern of these bins, as well as the bins used in other parts of the plant, are made of steel, flat topped, a cross section of one of them, as seen from the end, appearing as a half ellipse.

The second level from the top is that which contains the lower part of the storage bins and the upper part of the mixers. The stucco is drawn off from the bottom of the storage bins and fed into the upper half of Broughton mixers, which are large steel cones supported on the beam of a scale. When sufficient material has been allowed to run into the cones the scale automatically trips and shuts off the flow. The operator at this point then adds the retarder and the hair or fibre required for the particular batch going through at that time.

The purpose of the retarder is to slow up or retard the setting of the plaster to suit the conditions under which it is to be applied on the job. These conditions vary considerably in various sections of the country, and with different climates and temperatures and the local conditions peculiar to a particular piece of construction work. Pure calcined gypsum or plaster of paris, if it is of normal fineness (80 per cent passing 100 mesh) begins to set in about six minutes. This setting or hardening is the principal characteristic from which gypsum derives its economic importance, but like the desirable characteristics of other important substances the setting of this gypsum in a hard mass when combined with water must be controlled and held within limits to permit satisfactory handling of the finished product on the job. To control this setting characteristic the retarder is added.

This retarder is a slaughter house product of indefinite composition. The materials out of which it is made are chiefly hair, caustic soda and lime. It emits a very objectionable odor and is used in very small quantities, a slight amount of retarder being sufficient to control the setting of a large quantity of gypsum. A number of the larger manufacturers of gypsum products make their own retarder, but in most places it is purchased from outside concerns.

The methods of retarding and accelerating the setting of plaster have to do with the crystallization of the substance. The addition of a few crysals of set gypsum to the material will accelerate the set, thus hastening the action by forming nuclei around which the rest of the mass crystallizes. This principle is employed in the preparation of dental plaster, which is often accelerated to set in one or two minutes. Any material which tends to prevent crystallization will retard setting. In general, the addition of mineral substances accelerate and the addition of animal or vegetable substances retard. The rate of setting is apparently little affected by the addition of accelerators and retarders. The office that these substances perform is to change the time at which the action begins.

The hair or wood fibre that is added to the stucco at the same time as the retarder serves the purpose of bonding the material when it is applied to the wall. The hair, large quantities of which are used, is very carefully washed before it comes to the gypsum mill. Each mill usually manufactures its own supply of wood fibre, securing materials such as poplar and basswood in the neighborhood of the plant and shredding it to the necessary fineness with their own machinery. The fibre serves as an aggregate, like crushed stone or gravel in concrete.

When the correct amount of retarder and hair or fibre has been added to a batch of gypsum in the weighing section of the mixer the entire batch of material drops down to the mixing section of the mixer. Here the mass is thoroughly worked together and the retarder and fibre thoroughly disseminated.

The plain stucco, without retarder,

hair or fibre, may in most cases be drawn off from one of the bins in the mixer building and put up in bags. Provision is also usually made at an earlier part of the process to draw off ground raw gypsum for use as land plaster or Portland cement retarder.

After the gypsum has been thoroughly worked together in the mixer it is passed on to the bagging machine. Valve bag packers are used extensively around gypsum mills. as are also wire tied jute bags. Neat gypsum plasters are put up in jute bags holding 100 pounds or in paper bags holding 80 pounds. Shipments are also made in paper lined wooden barrels which hold from 250 to 320 pounds net. It is customary at most gypsum mills nowadays to furnish "ready mixed" plasters, to which sand has been added, in burlap bags of 100 pounds.

In most gypsum plants a very strict chemical control insures the production of satisfactory material. All the varying factors are kept under continual surveillance and physical conditions affecting the results are also carefully checked and controlled. Temperatures of dryers, kettles, kilns and calcining bins are carefully watched. Samples of the material at various stages in the process are being continually taken off and checked up for quickness of set and other characteristics.

Phosphate Rock and Its Production

A phosphate is a salt produced by the action of phosphoric acid on a base, or material of alkaline character, that is capable of being salified. Phosphate rock is a substance found in nature in which this process has been accomplished by natural means, a limey material being given a phosphatic character by phosphoric acid resulting from a number of causes. The components of the rock were, in most cases, deposited on the bottom of ancient oceans as the remains of the sea life of the time. Most of the remains of this prehistoric marine life were the bodies of crustacea, mollusks, snails and the lower forms of animal life that then prevailed. As these primitive organisms died they fell to the sea floors and were gradually imbedded in their landing places by the dead bodies of other organisms and by an ever accumulating fine precipitate that was thrown out of solution in which it was held by the sea water. In time these animal and precipitated accretions to the sea floors were changed by geological actions to limestone measures, and after countless ages assumed the dignity of separate strata. Other geological processes deposited strata of a different character and the phosphate bearing stratum was no longer the top layer. In some cases the upper layers have been eroded, in others the phosphate is still covered by strata of dissimilar materials. Sometimes, too, the process that terminated in one age began in another and we have phosphate rock in the same sections at different horizons.

Diatoms, minute plants provided with siliceous envelopes, are important agencies in the building of phosphate deposits.

The protozoa and other organic forms referred to above, mostly of gelatinous structure, yielded up some of their phosphatic constituents which, acting as phosphoric acid, produced tricalcic phosphates and the other substances found in phosphate rock. These were cemented together by silicious materials which became separated from the phosphatic substances and spread as a glaze over the minute particles. Countless years afterwards acid waters caused by the decomposition of the rank vegetation of the carboniferous or other ages percolated through to the phosphate-limestone foundation and leached out large parts of the material, leaving those which were covered by the silicous coating just referred to. This caused concentration of the phosphatic material and largely explains the condition in which it is found today. That phosphate rock was formed as a result of the decomposition of these ancient animal remains is proved pretty clearly by the fact that all sections of the country where the same geological measures occur vary in phosphate rock occurrence in direct ratio with the percentage of fossil remains.

This geological theory does not explain all phosphatic occurrences in all parts of the world, but it serves to give a general idea of how a large part of the material known to exist very likely had its origin. In some island of the South Seas immense deposits of phosphate there occurring are supposed to have been caused by the existence on those islands of an ancient bird life.

Phosphate rock is commercially valuable because it is the basis of a number of phosphates utilized to a great extent in our modern civilization. Chief among the uses to which it is put is that of a fertilizer. When used for this purpose it is either applied directly to the soil as a finely ground raw rock, or is treated with sulphuric acid to produce what is known as "acid phosphate," a substance manufactured and sold in large quantities and without which certain sections of this country could not today continue to furnish the products that are expected of them. A deficiency in plant food in many soils in the South can be made good only through the use of acid phosphate and other materials, such as potash, and nitrogenous matter. The raw ground material also has a field of usefulness, but is not so much in demand as the acidulated product.

The United States have, in all the

phosphate deposits of the country, the largest supply in the world. The deposits have been highly developed in a number of sections and furnish an enormous amount of material for use here and abroad. The principal deposits and producing centers will be described in the paragraphs immediately following.

By far the most important phosphate rock center, as regards extent of production, is Florida. Here four classes of material are obtained, hard rock, land pebble, river pebble and soft rock phosphate.

The hard rock phosphate is found bedded on lower Oligocene limestone and associated as boulders and pebbles with a soft matrix of phosphatic clays and sands. It runs as high as 85 per cent in tricalcic phosphate content, although as found associated with impurities it ranges between 19 and 30 per cent. Deposits are very irregular, occurring sometimes at the surface or close to it and sometimes so far down that they cannot be worked with any degree of economy. They extend in various widths over a section 100 miles long in the western part of peninsular Florida.

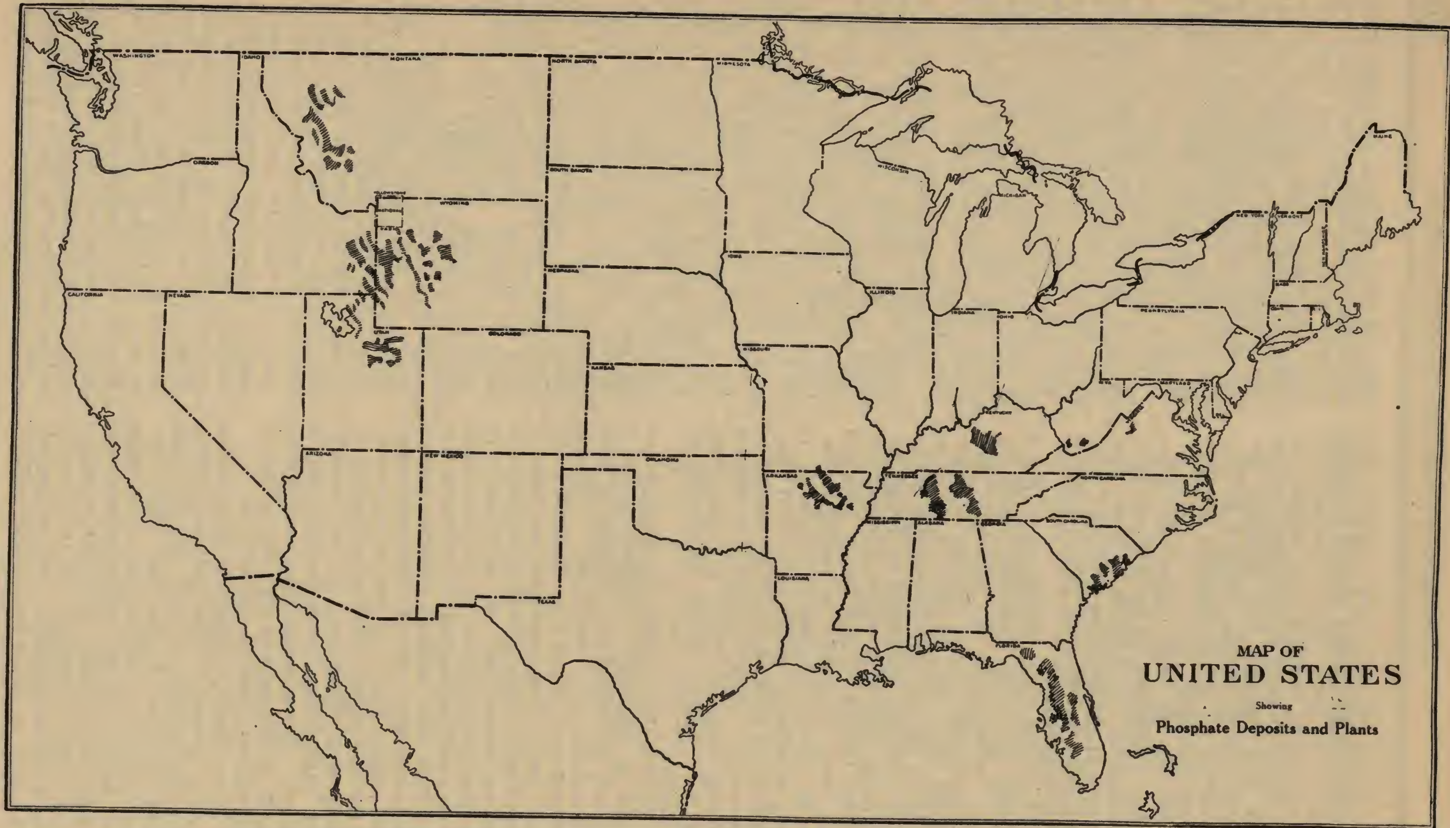
Florida land pebble phosphate occurs as rounded pebbles up to 2 inches embedded in a matrix of soft phosphate, clay and sand. Tricalcic phosphate content runs from 60 to 75 per cent. The more or less natural colorings range from light gray to blue or black. They are in much more workable deposits than the hard rock phosphate, laying in alternate layers of fine and coarse material, seldom running below 40 feet in depth, and averaging about 12 feet in thickness. Like the hard rock it is bedded in Oligocene limestone and is covered by sand which averages 15 feet in depth. Deposits of these pebbles lie east of Tampa in an oval area 40 miles long and 30 miles wide.

River pebble phosphate is deposited on river bars. The occurrence is as rounded pebbles or sand, running from the sand to 2-inch size. The percentage of tricalcic phosphate is from 55 to 65 per cent. The pebbles are ordinarily stained by organic matter, but these colorings do not extend through the pebbles. This phosphate material is found in variously colored clay and sand matrices and form parts of extensive accumulations of detritus brought down by the rivers from sections in which other kinds of phosphate are present. Deposits are not individually large or great in number and constitute a negligible part of the supply. Occurrences are chiefly on the Peace River and St. John's River and tributaries.

Soft rock phosphates are those parts of the matrices of hard rock and land pebble phosphates that have in themselves a phosphatic character. More of these parts occur with the hard rock matrix. They are mixed as a soft powder that is very plastic when wet and very dusty when dry. Much is lost in removing the clay of the matrix.

Tennessee phosphates are classed as "blue-rock," "brown-rock" and "white-rock." Blue rock, which is of sedimentary origin, is found associated with sand, gravel and clay. It is a tough, granular rock, running as high as 85 per cent tricalcic phosphate but more frequently containing as little as 30 per cent. Brown rock occurs as a material which disintegrates to phosphate sand and as a plate rock of varying thickness, the two ordinarily associated. Brown rock contains 70 to 80 per cent of tricalcic phosphate. White rock is not mined or sold in quantity. Blue rock is found in Lewis and Maury counties, around the Centreville district principally. Brown rock comes from a number of counties around Mount Pleasant in Maury county. Mount Pleasant is the important producing center.

South Carolina produces phosphate as land rock and river rock. The land rock is the undisturbed phosphatized Edisto marl, the river rock is made up of parts of the same deposit broken up or at best worked over by river action. The land rock occurs in irregular beds of uneven or jagged masses of honeycombed rock that is soft and chalky and light yellowish brown in color. The river rock is very irregular in distribution. It is most concentrated on river bottoms. Both kinds range from 55 to 64 per cent tricalcic phosphate. The zone in which all occurrences fall is along the Atlantic seaboard, 30 miles wide and running from Beaufort, 50 miles southwest of Charleston, to a


MAP OF
UNITED STATES
Showing
Phosphate Deposits and Plants

point about 20 miles north of Charleston. Production in South Carolina has practically been abandoned in the last few years and will probably not pick up, in spite of large deposits, until the more easily mined Tennessee phosphate is more nearly exhausted.

Phosphate rock is being produced in amounts that are becoming greater each year at points in Idaho and Utah. At Conda, Idaho, the Anaconda Copper Mining Company is mining a great deposit made up of sedimentary material, containing 70 to 76 per cent tricalcic phosphate and ranging from a soft substance to a medium hard one which breaks into small laminated blocks. As yet, though, the enormous Western deposits have hardly been touched.

There are other phosphate occurrences in Kentucky, Arkansas Wyoming and Montana. Amounts have been mined and shipped from these places but production does not amount to anything of importance. As more of what is now almost virgin land in this country comes to need phosphate, development in these places will undoubtedly be undertaken on a greater scale.

Operating methods in phosphate mining and mill operations vary as widely as do the characters of the various occurrences. The variations in methods are largely due to the difference in the occurrences and the local conditions surrounding the operations, but partly also to the fact that the industry came into being a comparatively short time ago and began as a series of local enterprises, in the founding of which each operator adopted the standardized machinery used for similar crushing, washing and screening operations, and added to them his own devices, developed as a result of his own experiences. This has resulted in a lack of standardization which is, however, gradually ironing itself out and will in the course of time disappear, leaving the industry operating in a standardized fashion, as is being done in quite a number of plants at the present time.

The first work that must be done, of course, if the operation is to be done above ground, is that of stripping. This must necessarily be handled in a variety of ways, dependent in each case on the surrounding conditions. Much that is said about stripping under the headings of "Crushed Stone" and "Sand and Gravel" applies here also.

In the Florida districts particularly, a great amount of the stripping is done hydraulically, as is also a considerable part of the actual work of excavating and conveying the phosphatic materials. Here heavy pressures are used, great streams of water leaving the nozzle and accomplishing the work with speed and economy. Where the overburden has a considerable amount of clayey constituents, it is frequently necessary to loosen it first by blasting. Sands and other less consolidated materials are disposed of very easily. Spoil areas are determined upon before the operation is begun and provision made for leading the stripped materials to them. Sometimes old pits are utilized for this purpose.

In other places stripping is done by draglines, steam shovels or scrapers. In these cases it is often customary to move the overburden to worked-over areas close by. This practice has, while it was economical some years ago, been the cause of adding to some present day mining costs. At that time the stripped material was put on worked-over sections that contained a considerable amount of phosphate, lower in grade than the operators of those days could economically handle. With the improved methods of the present in vogue, the material considered below grade then is valuable now and is being excavated at considerably increased costs because of the necessity of moving again the old overburden piled up years ago.

Excavation of the phosphate rock from open workings is accomplished in a number of ways. Hydraulicking is practiced to a considerable degree. So, too, is dredging, and the use of steam shovels, draglines, portable cantilever travelers and of hand methods, which are sometimes really necessary and economical, particularly where material is to be taken out of pockets roofed over by cap rock that cannot be economically dug out by a mechanical device operating from the top or side.

The work of hydraulicking for phosphate rock involves two separate operations, the pumping of a cutting

stream of water against the exposed phosphate and the later pumping of the loosened material from a sump to which it is conducted by runways. Besides being well adapted to operations in which, because of a broken or irregular bed rock, steam shovels cannot be used advantageously, this method has the advantage of a disintegrating action on the clay matrices in which phosphate is held. The contact with the strong stream of water and the continual washing action of the conveying current do much to break up a matrix and deliver at the plant a much cleaner product than could be taken out with the steam shovel or dragline. A disadvantage of the method is the necessity it imposes of providing and maintaining ditches or runways from the working faces to the sump. When the underlying material is hard the difficulty is greater, when soft, less. Hydraulicking can be practiced to advantage, of course, only when an advantageous arrangement of levels at working face, sump and plant can be worked out. Hydraulic mining pumps of various types are used for furnishing the cutting streams, centrifugal dredging pumps for raising the materials from the sump to the plant. These last are treated at some length under the heading of "Sand and Gravel."

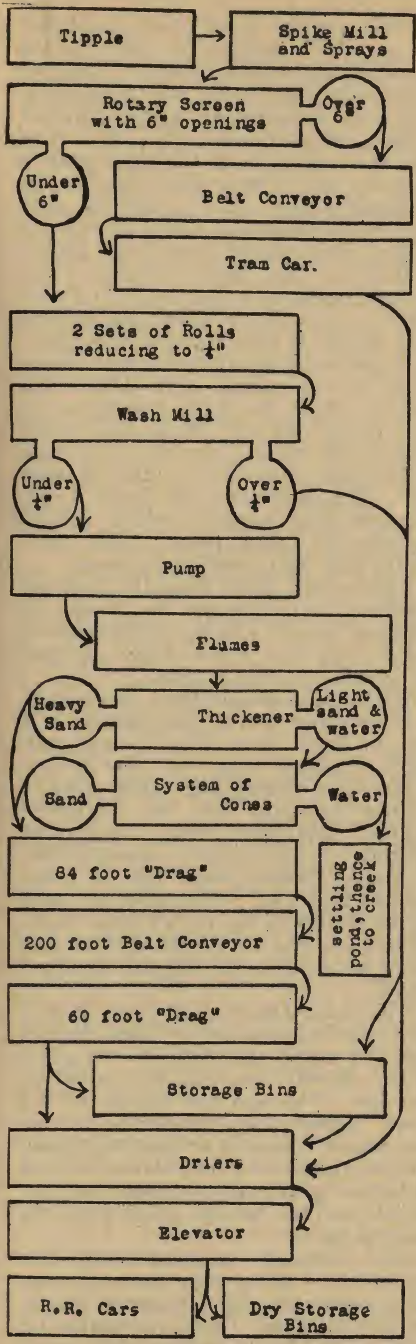
Draglines of the larger sizes are used considerably in excavating, these sometimes followed by mechanical devices designed to clean up material that the draglines cannot reach. One of these devices is the portable cantilever traveler, which consists of a portable overhead trackway along which runs an operator's cab. From this cab a skip is operated by wire cable, the skip being dropped into the workings around rocks near which the dragline cannot operate. This skip, when filled, is dumped into cars pulled alongside the traveler.

Underground mining methods are practiced to a considerable extent. These workings are usually of the "room and pillar" type, though not always so. Mines in some cases follow the best modern practice, with the latest mining equipment, including trolley or battery haulage systems, electric lighting and mechanical digging and loading equipment. In most cases, however, more simple methods are in force, with digging and loading done by hand and haulage done by mules.

Arrived at the plant, the phosphate rock is handled in many different ways. Sometimes washing is necessary and sometimes the material is handled in the dry state throughout the process. It is usual first to pass the rock through a roll crusher or equivalent device, called locally a "spike mill" or by some similar name. Sometimes, as in the Anaconda plant at Conda, Idaho, a gyratory crusher is employed. From this point on the procedure at an ideal dry plant would be somewhat as described in the succeeding paragraphs. In describing the operations the writer has in mind two modern plants utilizing modern machinery, one located in the Tennessee field and one in the West.

The material, at one of these plants, after passing over shaking grizzlies and going through the first reduction which takes it down to 2½-inch size, is elevated and passed over a vibrating screen. The screened under size goes directly to the dryer feed bin, while the oversize is crushed to ¾-inch size by 22x54-inch rolls, the product from which is elevated again to the vibrating screen. From the dryer feed bin the crushed rock is fed by an apron feeder to a rotary dryer. After leaving the dryer the rock goes over a shaking feeder to a chain bucket elevator which carries it over to the top of the mill and thence to a sampler. Then, by a system of conveyors it is deposited at any desired point in either of two bins with a capacity of 4,000 tons each. The ¾-inch material is then reduced to 60 mesh size by ball mills. After the ball mill operation the rock is ready for acidulation.

At the other plant the phosphate rock, after passing the primary crusher, is sent on to a single shell rotary dryer. Material is fed at the cold end, coming out dry at the firing end. This dryer is equipped with an exhaust fan which draws the hot gases through the cylinder and takes off the moisture. Dust from the drying operation is reclaimed by passing the blower output through a cyclone separator. Accurate check of the temperature in the dryer is kept



Flow Sheet of Tennessee Phosphate Plant

by a pyrometer and of exhaust gases by a recording thermometer. Another purpose served by the cyclone is to remove clay and low grade frustules. After going through the dryer and passing a rotary screen which separates at ¾ inch, the rock is sent to a hammer mill which takes it down to 60 mesh size. An air separator takes off the 200 mesh material and drops all the rest to a tube mill, which is operated to secure a number of fine sizes.

It may be remarked here that the fine reduction of phosphate rock is made very difficult by the fact that most of the tiny granules have a silicious coating which strongly resists the pulverizing action, particularly when the finely divided material "cushions" in the mill. Much of the dry material that is lighter than the phosphate rock is knocked loose in the rotary screens, picked up by air suction while floating in the air and removed through the discharge ends of the screens. Pulverizers are sometimes equipped with automatic throwouts which reject material too refractory for the pulverizers to handle.

In plants operating on the wet method the procedure is quite different. Here the idea is to clean up a clayey phosphate rock to make it suitable for acidulation. In the cases of the two plants described above, the first treats a rock that is clean enough for acidulation without washing, the second handles a rock that is ground for direct application. Descriptions of two wet plants that employ typical apparatus are given in succeeding paragraphs.

At the first of these plants there is a receiving hopper at the top of the washer building, so that a uniform feed of phosphate to the plant is obtained. The owners consider this very essential, as they at all times try to have a uniform stream of phosphate meeting a uniform flow of water from the pumps.

The phosphate is passed through two sets of double horizontal rolls of the company's own design, the lower set of rolls being spaced about three-quarters of an inch apart. From these rolls, the material drops to a "mulcher" of their own design. The object of this machine is to tear up the clay balls and properly prepare the phos-

phate for the process of separating the impurities. This machine approximates the action of a puddler in a brick-making plant. The material leaves this machine in about the consistency of a thick paste.

From here, it goes into an inclined revolving shell, which the company men call a "dasher," 6 feet in diameter and 20 feet long, with flights or lifters mixing the phosphate with the incoming water.

From this shell, the phosphate is discharged into an inclined revolving shell, 7 feet in diameter and 30 feet in length, partially enclosed in a large wooden box, into which fresh water flows. Partitions in this wooden box compel water to flow through the shell. The fresh water is entered at the lower end of the box and flows through the shell, meeting the phosphate coming from the dasher. In this way a counter-current washing action is obtained and here the first roughing off of the impurities and fine phosphate sand is obtained.

To the end of this washer shell a circular screen of ⅝ inch mesh, 4 feet in diameter and 3 feet long is bolted. Here a separation of the sand and lump takes place. The lump is conveyed by a chute to a bucket conveyor and thence to a picking belt, where clay balls and flint impurities are rejected by hand. No further work is done in washing or crushing the lump.

The sand which goes through the screen is taken up by two hydraulic jets and discharged into two 8-foot sand cones. The overflow from these sand cones returns to the rear end of the washer box.

The sand discharged from these cones drops by gravity into a small specially designed machine called a "rubber" resembling the "mulcher" mentioned above. This machine rubs off the last of the adhering impurities on the sand grains.

The fine sand which goes off with the muddy water from the front end of the washer box is discharged into a battery of six 14-foot sand-washing cones. In these cones, the final separation of the impurities and fine phosphate sand is obtained. This part of the system must be carefully watched, as the specific gravity of the impurities is almost the same as of the fine phosphate sand.

The overflow from these cones goes to an 8-inch centrifugal pump and is pumped to settling ponds. The fine phosphate sand from the sand-washing cones is discharged by jets into an 8-foot sand-dewatering cone. The water overflow from this cone goes to a pump and is then discharged to the settling ponds. The underflow runs to a button conveyor which discharges it into the "rubber" mentioned above.

Here all the sand is mixed. The rubber discharges into a pit. Fresh water at the rate of about 500 gallons per minute is added, and a 6-inch centrifugal sand pump elevates the mixture to two 8-foot sand dewatering cones. Here the final separation of the sand and its impurities takes place. The water overflow from these cones goes back to the large washer box. The sand from the cones is discharged into hoppers where partial dewatering takes place. This completes the sand-washing process.

The muddy water from the washing process is discharged by flume to settling ponds where the impurities settle and the clear water returns by gravity to the pumps.

The lump and sand from the washer is discharged into a skip located in a pit and from there it is dumped into large draining bins over the dryers, where final dewatering takes place.

This company has two cylinder dryers equipped with underfeed stokers. Each dryer discharges into a hopper which feeds into a drop-bottom skip car. This skip car goes up an incline to the top of their stock-house and can be discharged at any point by means of a tripping arrangement.

The stock house is of novel design. The roof is supported by steel trusses which parallel the slope of the piles. About 12,000 tons can be carried in storage. Through the center of the stock house runs a concrete tunnel, the top of which is at the floor level. In this tunnel is a belt conveyor with gates every few feet so that the material can be fed by gravity to the loading belt.

The company operates an electric car loader. They also have a magnetic pulley on their shipping belt to remove all iron. Cars are spotted on track scales for loading so that maximum car loadings can be obtained.

The capacity of this plant is from 300 to 350 tons of finished product.

In another wet plant, utilizing a somewhat different method, material is brought to the plant in end-dump cars containing about 2¾ cubic yards each. A friction hoist at the top of an inclined trackway is used to haul the cars up to a spike crusher. This crusher reduces the stone to 6-inch size and it is then passed to an 8-foot rotary screen. Three jets of water are blown into this screen while the crushed rock is being turned over in it and wash it very thoroughly.

Two sets of rolls next take up the work, reducing the material to ¼ inch. It is then passed to the wash mill and thoroughly washed. Rejections from the screen, which passes rock less than 6-inch, are thoroughly rewashed to remove all foreign adhesions and sent by a conveyor to tram cars which dump at the driers.

The smaller material, which is likely to contain a larger amount of foreign substances, offers a much more difficult problem. It involves the work of clay elimination and sand separation and both of these processes must be gone through very thoroughly before the phosphate is in proper condition for the dryers.

The elimination of clay is the most difficult and exacting operation carried on in the whole plant and calls for the use of some very ingeniously designed machinery. The first of these is a large octagonal washmill in which the phosphate and the water are agitated by a system of chains and draw bars. These last act as beaters, each of the chains and bars giving the mass 8 knocks in one of its courses around the mill. This action has the effect of reducing nearly all of the clay to solution and permits its being run off through a spillway at one of the 8 sides of the mill.

After the material has been thoroughly washed a gate is opened and everything under ¾ inch is permitted to go direct to the large settling bins, where it remains for from 24 to 36 hours. It is then taken up by a 6-inch centrifugal pump and passed into flumes which lead to the large "drag" where all the remaining clay is removed. The "drag," as it is called at the plant, is an 84-foot conveyor with scrapers 66 inches wide which give each bit of material that goes through the device 84 vertical squeezes, rubbing out the clay under enormous friction and passing the phosphate to a conveyor belt 200 feet long and 22 inches wide.

The water from the flumes that feed this drag has a large amount of valuable sand in it and provision is accordingly made for salvaging. This water flows into a thickener, where it is rewashed and concentrated. It is then put through a system of sand separating cones which save the valuable phosphate sand and pass it back to the big "drag." Sand so fine that only 1.9 per cent stays on a 100-mesh screen is saved by these cones and the waste overflow contains nothing but clay.

After the "drag" has passed the material to the 200-foot conveyor belt, this latter carries it to another "drag" 60 feet long with scrapers 24 inches wide, which still further purify it, removing all vestiges of clay and delivering to the driers or storage bins a phosphate rock free of foreign substances.

At the storage bins or dryers it meets the rewashed material rejected by the rotary screen early in the process and carried by tram car conveyor to the storage bin or dryers. It also meets here the material over ¼ inch which did not pass the screen at the wash mill.

Before it goes to the dryers the phosphate contains from 22 to 25 per cent of moisture. The dryers reduce this moisture to the amount guaranteed in the sale, usually about ½ of 1 per cent.

There are two dryers with a capacity of 150 tons each for a 10-hour day. These dryers are 40 feet long, 6 feet in diameter and are equipped with forced draft systems.

Within the next few years the phosphate rock industry will undoubtedly adopt more progressive methods. Founded as it is on one of the basic interests of the country, agriculture, it will become more efficient as the demands of agriculture increase. Operating methods will be standardized to a greater extent to provide in greater quantities a material whose importance is increasing every year.

Silica and Its Method of Production

Silica is an oxide of silicon, the element which is, next to oxygen, the most abundant in nature. Silica occurs native in at least three forms—crystalline, amorphous and vitrified silicates. Good silica sands are obtained from rocks containing quartz and flint. For the purpose of glass manufacture, however, it is necessary that quartz be not only an essential constituent of the rock, but that it be practically the only constituent. Types of rocks suited for this purpose are found only in the case of certain sandstones, among the sedimentary rocks, and frequently these sandstones analyze about 99 per cent pure silica.

Sedimentary rocks are produced chiefly from materials furnished by the mechanical disintegration and chemical decomposition of rocks existing on the earth's surface previously to the beginning of this action. The chief agents in the accomplishment of these processes are temperature changes, frosts, rains and gases. These produce in the original rocks an alteration that is known as weathering. Temperature changes and frosts are the most active of the agents in producing mechanical disintegration, causing cracking and breaking of massive rock into small fragments.

As a result of this weathering process a large amount of material accumulates where the various agents of transportation are not sufficiently active to remove it as it comes. This material is a soil which is made up largely of altered fragments of the original rock. On these products of decomposition and disintegration, the gases present in the atmosphere exert a steady persistent influence finally resulting in the production of materials differing in character from the original. For example, a soil containing orthoclase, a very common soil constituent, was acted upon by the weather and the carbon dioxide of the atmosphere to form kaolin, silica and potassium carbonate, as shown by the following formula:

$$2KAlSi_3O_8 + 2H_2O + CO_2 = H_4Al_2Si_2O_9 + 4SiO_2 + K_2CO_3$$

After the reaction has been accomplished, the kaolin will remain behind in the soil as a soft clayey mass. Part of the silica, at least the more soluble parts, will be carried away in part, in solution, by surface waters, to be precipitated at lower levels in the form of quartz. Once precipitated it strongly resists weathering and remains unaltered by the continuation of the process which produced it. A considerable part of it is also left behind in its original condition as a residual material formed after the process of weathering had been completed.

Most of the other rock making minerals are subjected to a process similar to that undergone by the orthoclase, and as a result soft mixtures of sand and clay are produced. At the present time consequently, quartz in the form of small grains is found distributed through soft clayey materials. In some cases these clays and other impurities have been removed by natural processes and the deposits are today almost pure beds of silica.

One of the most important transportation agents found in nature is running water and through the action of this running water many deposits which contained silica in association with clayey material were attacked. Rain washed large amounts of materials into little streams which came together in rivers. In this process of carriage by the stream, considerable amounts of the material got into the solution and other parts were worn by attrition. The quartz crystals resist this action better than any of the minerals with which it was commonly associated and as a consequence, survived. When the streams carrying these grains of quartz had their velocity and volume checked in some way, deposition occurred, the coarser and heavier material falling first, and the lighter and finer dropping on top of it.

The coarsest materials in the quartz group, which are gravels, would naturally fall first. Next would come the more sandy materials. Last, are deposited the very fine materials, the silts and muds which settle out when the velocity of the stream is reduced very low. These places where quartz

deposition occurs most frequently are aluvial plains. Another point of deposition of silica is where the stream enters a body of standing water. Other occurrences are at places where the groove of an ancient river bed has been cut down by geological changes, involving the remaining of the water at the source, or the change in the formation of the river bed itself, brought about by natural processes.

Quartz laid down at the mouth of the stream where it enters a body of standing water, is sorted very finely. Where the stream enters a large lake or ocean, sorting and washing was assisted by wave action, including rising and falling of tides and the shore currents. The wave action wears the material down finally, until nothing but the hard quartz remains behind. The Oriskany sandstone in central Pennsylvania represents deposits of this kind from along the shores of the early Devonian sea. It is said that the Florida Gulf Coast around Pensacola is gaining at the present time accretions of silica sand containing over 99 per cent silica.

Sorting and transporting are also accomplished to a considerable extent by wind action, alone and in conjunction with running water. The combination of these two methods results in the accumulation of very pure quartz sand. Sometimes the wind picks up quartz materials at the place where the disintegration and decomposition of the original rocks took place, sometimes at a point to which the quartz is brought by water transportation. When steady winds in one general direction are blowing, they carry the sand along and heap it in the form of dunes, such as are commonly found along the Rio Puerco valley in Arizona. There is not, however, the fine separation of fine and coarse material that there is in deposits that have been handled by water transportation. Low lying plains frequently contain considerable wind blown quartz. The St. Peter sandstone which forms the sources of glass sand around St. Louis and in the Ottawa district of Illinois, is an example of rock formed from a wind blown sand deposited on the low lying plains which occupied the upper Mississippi valley region during the early part of the Ordovician period.

In general the water carried and wind blown quartz sands may be distinguished from one another by the fact that the wind blown materials are usually round and are so rubbed by attrition that the surface of the grains assumes the appearance of ground glass. Water laid sands are sharper and more or less angular because grains of ordinary size are protected from abrasion by the cushion of the water around them. This is practically true of the smaller sizes.

Sands deposited to considerable depths over gradually subsiding areas were frequently associated during deposition with an amount of clayey material which on the application of sufficient pressure made possible the consolidation of the mass into rock. Mineral matter like calcite, dolomite, silica and iron oxides also had a tendency to bind the sands together after these minerals had been deposited between the grains from water solutions percolating through the sands. Sandstone cemented by iron oxide is inferior for glass making, but may be used for a number of other purposes.

The sandstone deposits formed by the pressure of overlying materials upon the deep lying sands were frequently raised to heights above sea level, each erosion often removing the overlying sediments and again exposing the sandstone at the surface. Sometimes, too, material combined through the horizontal layers of rock into a series of anticlines and synclines (arches and troughs). Beds of these in many places are tilted at various angles. This process of elevation above sea level, and the consequent exposure to weathering, has the effect frequently of disintegrating the stone and reducing it again to the condition of sand. The extent to which this occurs in any particular sample of stone, will depend pretty largely upon the bonding material that cements the separate grains of sand into stone. A calcite bond permits the disintegration at a much more rapid rate than is the case where the bond is of iron oxide, silica or clayey material. Sandstone is thus a very friable material that can be crushed without great difficulty.

Diatomaceous earth, called also by the German name of "kieselguhr," is composed of the silicious remains of

diatoms, aquatic plants of microscopic size. The plants secrete silica and build up a shell of the substance around themselves. Accumulations of these diatoms formed big beds of diatomaceous earth, the organic matter disappearing and the silicious alone remaining. Chemically diatomaceous earth is, aside from its impurities, a hydrous silica.

Quartzite is a metamorphosed rock, a quartz stone high in silica formed by the deposition of secondary silica between the sand grains of the original rock, the silica cementing the grains together into a hard stone.

Tripoli is an incoherent, highly silicious, sedimentary rock formed by the decomposition of flint. It is sold sometimes as rottenstone.

Silica sand is used principally in the making of glass, which contains 60 to 75 per cent of this substance. It is also used largely as a mineral filler in paints and in the production of mechanical rubber. American silica is replacing French calcined flint in a number of porcelain manufacturing industries. Another large field of silica sand uses is furnished by steel, iron and brass moulding foundries. Each one of these places demands a great deal of sand. Sands for polishing are also in great demand. Only a sand that consists of the sharp grains of pure quartz can be economically used for a polishing agent for metal surfaces, stones, marbles or glass. Various sand blasting processes also furnish a market for the silica sand produced. It may be said in general that good silica imparts strength to almost anything with which it can be mixed.

Silica that is intended for glass making may be used in the form of quartz or silica rock, in the form of sandstone rocks composed of the quartz grains, or of the wind or water deposits of sand described above. The finer the glass that is to be produced, the purer must the silica be. Iron oxide is undesirable because of its strong coloring properties. Alumina, too, is undesirable. These substances, where they occur to a great extent in the clay, must be washed out carefully.

Paint makers divide silica into two classes—hard and soft. The hard silicas include the crystalline and vitreous kinds such as quartz and flint, and the soft include the amorphous variety, particularly those produced by the weathering of rock and by deposition from solution. Hard silicas are used in paint known as paste wood filler and filler stains in paste form. The soft silicas are applied mostly in ready mixed fillers and filler stains. They are also utilized as general inert extenders whenever such extenders are desirable.

Sands intended for polishing must consist of sharp grains of pure silica. Quartz is the only form that can be used. This alone is hard enough to do the work. Uniformity of size is an important thing in sands prepared for this purpose. If materials are not fairly uniform, the surfaces of the articles being polished may be scratched. Highly colored sands are undesirable, though washing may make them usable, if the colors are due merely to materials easily removed or to stains in the crystals. The ball or tube mill is usually utilized to produce finenesses which must in most cases pass a 200 mesh screen.

Large amounts of silica sand are also used in the manufacture of pottery, scouring soaps, foundry mold washes, in metallurgical and chemical processes and for cosmetics and dentifrices.

During 1921 production was reported in California, Connecticut, Maryland, Michigan, New Jersey, New York, North Carolina, Pennsylvania, Washington, West Virginia and Wisconsin. The material produced in greatest quantity was silica produced from sandstone or mined as sand. Next in importance was diatomaceous earth, followed in the order of production by tripoli and quartz rock of the pegmatite, vein and quartzite varieties. Of the states mentioned above, some showed a very low production, the bulk of the material coming from a comparatively few localities.

Pennsylvania looms large among states producing silica sand as do Illinois, West Virginia and Ohio. The Pennsylvania and West Virginia producers are securing their material chiefly from the same formation. The Illinois production comes chiefly from the celebrated Ottawa district, where

huge deposits of silica, chiefly wind blown, are located. Ohio comes in for a good tonnage, the product used mostly as a molding sand.

Production methods in the silica industry differ in many particulars, a certain part of which differences can be explained by the differences in the occurrences, but partly by reason of the fact that operators using different methods have, after long operating experiences, found them satisfactory.

In Pennsylvania, where the silica occurs as quartzite or as a softer sandstone, production methods call principally for the use of chaser mills and screw sand washers, with initial breaking handled mostly by jaw crushers, and in a number of cases by gyratories. In Illinois, where the silica is usually found as a sand, the material, after being brought up to the plant by one or another of the methods usually employed in excavating sands, is ordinarily put through a washing process that involves the use of settling bins, as will be described later. Drying is done with rotary dryers or stationary steam dryers consisting of parallel series of steam pipes through which the sand drops and is by this action dried.

A typical operating method much in use in parts of Pennsylvania would be somewhat as follows: The stone after being quarried and hauled to the plant, is fed to a jaw crusher which reduces it to about 2½ inch size. After this a chaser mill or dry pan takes up the work. This device employs as the active grinding agencies two large steel rolls or mullers mounted on bearings at the ends of a common axle which rotates horizontally on a bearing at its center. These rolls run about 48 inches in diameter and have faces 10 or 12 inches in diameter. These rolls run around in circular pans 9 or 10 feet in diameter. The stone is introduced with water and the action of the rolls reduce it to the fineness desired. This fineness varies over a wide range, depending upon the purpose which the sand is to serve; if for glass making, upon the kind or quality of glass to be made. After the desired reduction is accomplished the sand is let out through screened openings at the side of the pan and passed on to the washing operation.

The washing is usually done with sand washing screws whose continuous helical blades arranged about a shaft force the material up an inclined trough against a stream of water introduced at the higher end. This action carries away the soluble clayey material occurring with the sand and dumps the washed product over the higher end of the trough. These washers are frequently arranged in batteries and dump in piles along a straight line in such a way as to permit easy conveyance on to the drain bins or drain floor.

In some plants, instead of the dry pans, are pulverizers with revolving rings of manganese steel or semisteel chilled iron which grind by impact. The stone is introduced between the rings and grate bars of manganese steel, which the rings do not touch. Another grinding device for the work of reducing the sand is a disintegrator which operates by catching the sand between two sets of spokes, arranged in relation to one another as the staves in a straight sided barrel, with spaces of about 4 times the diameter of a spoke between each pair of spokes. The two sets revolve, one within the other, in opposite directions.

In place of the sand washing screws are sometimes employed washing devices utilizing a water jet. Each one of a series of iron boxes arranged in a circle or in rows is equipped with a water jet eductor. In the first box the sand to be washed is stirred at the time it is admitted by a jet of clean water. The sand is then lifted out by a clean water jet eductor and deposited in the second box in which, being heavy, it immediately falls to the bottom. The violent stirring action mixes the water with the clayey material and causes it to overflow near the top. This process is repeated through as many boxes as it is thought necessary to pass the sand to wash it sufficiently. The washing is thus accomplished by clean pressure water without the aid of mechanical appliances.

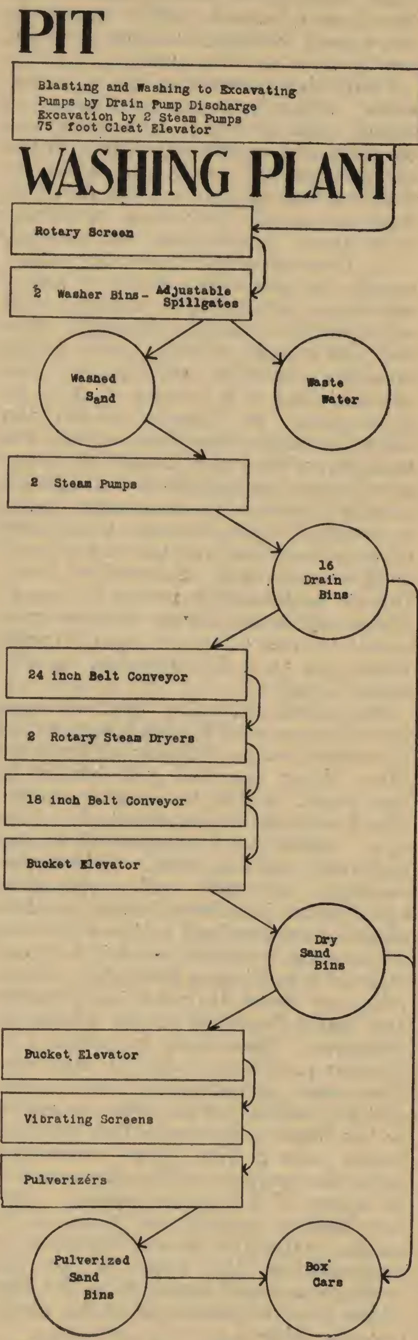
Another device used for washing the sand is the hydraulic classifier which is effective in saving the fine sands. The classifier operating method calls for the introduction of sand and water at the same time, the action

of the water washing out the clay materials and fine sands. A continuously operating system of rakes brings the coarser materials and settled sands up an incline and gives them a thorough scrubbing on the way. The incline extends above the level of the water in the classifier and in this way the material is removed after the washing operation is complete. The fineness of the materials recovered depends upon the regulation of the current of water.

A number of types of dryers are used for removing moisture remaining after the sand has been taken from the drain bins or drain floor. The steam dryer, the latest development, is used to a great extent. This piece of equipment consists of tiers of horizontal steam pipes resting on angle irons and enclosed in a brick structure. The tiers are arranged one above the other, and the various tiers are spaced closer together at the bottom than at the top. Sand drops through the tiers of steam pipes from a belt conveyor running above, is dried in its downward course between the heated pipes and is drawn off in thin streams on a belt conveyor running below the dryer parallel to the steam pipes. The steam and damp air resulting from the drying are taken off by an exhaust fan. Direct heat dryers are also used. These are essentially revolving steel cylinders inclined so as to let the sand introduced at the higher end find its way to the lower when the cylinder is revolved. The heat used is furnished by the hot air and gases of combustion. A combination of these two methods is a rotary dryer with steam pipes running on the inside after the manner of flues in a horizontal boiler.

After the drying operation the sand is a finished product and is passed on to bins from which box cars, papered inside as required by specifications, are filled.

At silica sand operations in the Ottawa district in Illinois the material is taken out by dragline scrapers, pulsometers, steam suction pumps and by other means commonly employed to excavate sand. Dynamiting and hydraulicking are resorted to for the purpose of bringing down sufficient loose material for the excavating and conveying devices to handle. Arriv-



Flow Sheet of an Illinois Silica Plant

ing at the plant, the sand and water are let into large washer bins, each of which has an adjustable spillgate in one corner over which run the water that has by its movement through the sand washed out the impurities. From these washers the sand is picked up by steam pumps or pulsometers and sent on to drain bins which are also equipped with adjustable spillgates in one corner. From the drain bins, the material travels to the dryer and from here, through bins, into railroad cars.

Plants in other parts of the country use flumes with baffles arranged at convenient positions for washing the sand and separating various sizes. In some plants operating for the production of washed and ground amorphous silicas, the drying is done in comparatively shallow concrete vats along the bottoms of which run rows of steam pipes.

The various varieties of silica repulverized to all degrees of fineness to meet the requirements of users in many industries. Grinding is sometimes carried to a point where considerable of the material will pass 250, 350 and 450 mesh.

The principle uses for silica are given below:

Abrasive Uses.

In scouring and polishing soaps and powders.

Quartz, quartzite, flint, chert, sandstone, sand, tripoli and diatomaceous earth; all in finely ground state.

In sandpaper.

Quartz, quartzite, sandstone and sand.

In sand blast work.

Quartz, quartzite, sandstone and sand, crushed into sharp angular grains uniform in size.

For sawing and polishing marble, granite, etc.

Sharp, clean sand graded into various sizes.

As whetstones, grindstones, pulpstones, oil stones, etc.

Massive sandstone from very fine to moderately coarse grained.

Tube mill lining.

Chert, flint and quartzite in dense, solid blocks.

Tube mill grinding pebbles.

Rounded flint pebbles.

In tooth powders and pastes.

Refractory Uses.

In making silica fire brick and other refractories.

Fairly pure quartzite known as gannister; not less than 97% SiO_2 nor more than 0.40% alkalies, tightly interlocking grains desired.

Metallurgical Uses.

In making silicon, ferro-silicon and silicon alloys of other metals such as copper.

Moderately pure sand and massive crystalline quartz.

As a flux in smelting basic ores.

Massive quartz and quartzite.

Foundry mold wash.

Ground sandstone and quartz.

Foundry parting sand.

Fine sand and ground tripoli.

Chemical Industries.

As a lining for acid towers.

Massive quartz or quartzite.

As a filtering medium.

Massive diatomaceous earth and tripoli, sand, finely granulated quartz or quartzite, finely ground tripoli, diatomaceous earth and other forms of silica.

In the manufacture of sodium silicate.

In the manufacture of carborundum.

Paint.

As an inert extender.

Finely ground crystalline quartz, quartzite and flint often preferred; also finely ground sandstone, sand and tripoli.

Mineral Fillers.

As a wood filler.

As a filler in rubber, hard rubber pressed and molded goods, phonograph records.

Ceramic Uses.

In pottery industry as ingredient of bodies and glass.

Flint and chert, and other amorphous silica preferred.

In the manufacture of ordinary glass.

Pure quartz sand.

In the manufacture of fused-quartz chemical apparatus, such as tubes, crucibles and dishes.

Very pure massive quartz preferred.

Insulation

Heat insulation for pipes, boilers, furnaces, kilns, etc.

Car Demurrage Rules

Extracts from National Car Demurrage Rules,*

And Digest Showing General Application Common to the

Cement, Gravel, Gypsum, Lime, Sand and Stone Industries, On All Trunk Line, and Most Short Line, Railroads

"The purpose of demurrage charges is to promote car efficiency by penalizing undue detention of cars. The duty of loading and of unloading carload shipments rests upon the shipper or consignee. To this end, he is entitled to detain the car a reasonable time without any payment in addition to the published freight rate. The aim of this code was to prescribe rules, to be applied uniformly throughout the country, by which it might be determined what detention is to be deemed reasonable. In fixing the free time, the framers of the code adopted an external standard, that is, they refused to allow the circumstances of the particular shipper to be considered. When they prescribed forty-eight (48) hours as the free time, they fixed the period which, in their opinion, was reasonably required by the average shipper. The framers of the code made no attempt to equalize conditions among shippers.

"It was obvious that the period fixed was more than would be required by some shippers, most of the time, and that it was less than would be required by some shippers, most of the time. Among the reasons urged for rejecting consideration of the needs or merits of the individual shipper, was the fear that, under the disguise of exempting shippers from demurrage charges because of conditions peculiar to them, unjust discrimination and rebates to favored shippers might result." (The United States Supreme Court in "Pennsylvania R. R. Co. versus Kittanning Co.," 253 U. S. 319.)

RULES AND CHARGES TO APPLY

In its Conference Ruling of October 7, 1919, the Interstate Commerce Commission holds that Rules and Charges pertaining to Demurrage contemporaneously in effect with the accrual of the Demurrage will control. In other words, if Demurrage accrues on a car on January 5, 1922, the rules and charges in effect on that date must be observed, even though the rules or charges or both may have been different at time shipment left point of origin, or the date it arrived at destination.

QUESTIONNAIRE

CARS

	See Rule No.
What cars are subject to Demurrage Rules and Charges?	1-A
What cars are not subject to Demurrage Rules and Charges?	1-B
Under what conditions are privately owned cars subject to Demurrage?	1

FREE TIME ALLOWANCE

How long may a shipper detain a car before demurrage will accrue?	2-A
What do the terms "Loading" and "Unloading" include, in addition to physical handling of the shipment?	2-A
How, if a car is unloaded, then reloaded?	2-A
Suppose a car has been placed on an industry track and is afterwards switched to a new location to complete loading or unloading, how much free time allowed?	2-A
Do you get any free time for reconsigning?	2-B
Suppose a car arrives at destination via Road A, is held by that line for payment of charges, or surrender of bill of lading, and is then switched to Road B for delivery to consignee, how much free time allowed?	2-B

COMPUTING TIME

How is time computed on cars held for "Loading?"	3-A
How is time computed on cars held for Orders, B/L, Charges, etc?	3-B
How is time computed on cars held for Unloading on Public Team Tracks?	3-C
How is time computed on cars held for Unloading on Private Industry Tracks?	3-D

*The complete rules are as published in J. E. Fairbank's Tariff No. 4—Series I. C. C. No. 1134.

NOTE: The above are some of the principal elements involved in demurrage matters, and are all fully explained in the following Digest. For a more extensive description of Demurrage rules, the reader is respectfully referred to Agent J. E. Fairbank's Demurage Tariff No. 4, I. C. C. No. 1134.

DEMURRAGE RULES

Digest and Application

Rule 1.—Cars Subject to Rules.

Cars of either railroad or private ownership held for or by consignors or consignees for loading, unloading, forwarding directions, or for any other purpose, except as follows:

1. When cars are under load with railroad company material for use of and consigned to the railroad in whose possession cars are held. Example: If Brown & Company load sand on Wabash tracks for use of the Wabash Railroad and issue billing consigning car to the Wabash, that car will not be subject to demurrage.
2. When a private car—that is, a car owned by some one other than a railroad —is on its owner's private track, it is not subject to demurrage. Example: If Brown & Company own their sand cars and load them on their own

private track, that is, a track in which the railroad owns no interest, those sand cars on that track will not draw demurrage.

Rule 2.—Free Time Allowed.

(a) Forty-eight hours' (two days) free time will be allowed for loading or unloading.

"Loading" also includes time of furnishing forwarding directions on outbound cars, that is, the billing must be done within the forty-eight hours' free time allowed for loading, or demurrage will accrue.

"Unloading" allowance contemplates no extra detention of the car for:

1. Surrender of bill of lading on cars billed "to order" or "shipper's order notify."
2. Payment of freight charges when required prior to delivery of car.
3. For giving the railroad instructions to "turn over" car to another party after car has been placed for delivery and no extra movement of car is involved. All of these things must be accomplished within the forty-eight hours' allowance, or demurrage will accrue.

When the same car is both unoaded and reloaded, each transaction will be treated as independent of the other. This will also apply to industries performing their own switching service, but the industry must notify the carrier of time and date of unloading. In the above transactions, forty-eight hours' free time for "unloading" and a like amount for "loading" will be allowed.

Industrial Switching of Cars in Same Yard or Industry—Demurrage.

When a car held for loading or unloading is moved by railroad or private power to another point in the same yard or industry to complete loading or unloading, only forty-eight hours' free time will be allowed for the entire transaction.

Cars Diverted or Reconsigned.

(B) Twenty-four hours' (one day) free time will be allowed for the purpose of diverting or reconsigning, or for holding a car in transit on the order of the consignor, consignee or owner.

(As to just what constitutes "'Diversion" or "Reconsignment," see elsewhere in this volume.)

Cars Destined for Delivery to or for Forwarding via a Connecting Line will be entitled to one day, twenty-four hours, free time while such car is being held for surrender of bill of lading, or payment of freight charges before delivery to such connection. Example: Car arriving in Chicago via the B. & O. is held for payment of crarges before delivering to the I. H. B. for final placement. The B. & O. will allow one day and the I. H. B., two days' free time on the car.

When Cars are Held to complete loading or to partly unload, while in transit, twenty-four hours' free time will be allowed for such service.

Freight in Bond.

On cars containing freight in bond for customs entry and Government inspection, twenty-four hours' free time will be allowed.

Rule 3.—Computing Time Sundays and Holidays Not Counted Except Under Average Agreement After 4 Days' Debits Have Accrued. (See Rule 8.)

1. Cars held for Loading.

Time is computed from first 7:00 A. M. after placement on public-delivery tracks and without notice to the consignee of placement. If placement is not made in twenty-four hours after 7:00 A. M. of the day car is ordered set, the carrier will give consignee notice of placement.

2. Cars held for Orders, Surrender of B/L or Payment of Charges.

(a) Compute from first 7:00 A. M. after day on which notice of arrival is sent or given. (Placement of car on private siding is equivalent to notice of arrival.)

(b) Deduct time of carrier after disposition is furnished, and charges paid, until car is made accessible for unloading.

(c) Disposition orders sent by mail or wire will release car at 7:00 A. M. of date agent receives same, if sent the day before. If agent receives same on day sent, car will be released at next 7:00 A. M. and the time

will be chargeable to the carrier until placed for unloading of constructively placed.

3. Cars held for Unloading (and not for Orders, B/L, or Charges).

Team-Track Delivery—Compute from first 7:00 A. M. after public-delivery track placement and after the day on which notice of arrival is sent or given. If car is not placed within twenty-four hours after notice of arrival, the carrier will notify you when car is placed, and until it sends such notice in such cases, demurrage does not accrue. When such notice of placement is sent, compute from first 7:00 A. M. thereafter.

Private or Industry Track Delivery. Compute from first 7:00 A. M. after date of actual or constructive placement. (See Rule 5.)

Rule 4.—Notification.

Section A—Of Arrival. Notice of arrival shall be sent or given consignee or party entitled to receive same by this railroad's agent in writing or, in lieu thereof, as otherwise agreed to in writing by this railroad and consignee, within twenty-four hours after arrival of car and billing at destination, such notice to contain car initials and number, point of shipment, contents and if transferred in transit, the initial and number of original car.

Section B—Of Cars Stopped in Transit. When cars are ordered stopped in transit, notice shall be sent or given the party ordering the cars stopped upon arrival of cars at point of stoppage.

Section C—Delivery of Cars on Other-than-Public Tracks. Delivery of cars upon other-than-public-delivery tracks or upon industrial interchange tracks, or written notice sent or given to consignee or party entitled to receive same, of readiness to so deliver, will constitute notification to consignee.

Section E—When Carload freight is refused at destination, notice of such refusal shall within twenty-four hours thereafter, be sent by wire to consignor, when known, at his expense, or when not known, to agent at point of shipment, who shall be required promptly to notify the shipper, if known.

When other carload freight is unclaimed within five days from the first 7:00 A. M. after the day on which notice of arrival has been sent or given to the consignee, a notice to that effect shall be sent by wire, as provided in Paragraph 1 of this section.

Rule 5.—Placing Cars for Unloading.

The Constructive Placement Rule.

Section A—When delivery of a car consigned or ordered to an industrial interchange track or to other-than-a-public-delivery track cannot be made on account of the inability of the consignee to receive it, or because of any other condition attributable to the consignee, such car will be held at destination or, if it cannot reasonably be accommodated here, at the nearest available hold point, and written notice that the car is held and that this railroad is unable to deliver will be sent or given to the consignee. This will be considered constructive placement. (See Rule 3, Section D.)

On a car to be delivered to a switching line for final delivery and which consignee located on switching line is unable to receive and which for that reason the switching line is unable to receive from this railroad, notice will be sent or given the switching line showing point of shipment, car initials and numbers, contents and consignee, and if transferred in transit the initials and number of the original car.

When this railroad is the switching line and, under conditions set forth in Paragraph 1, is unable to receive cars from a connecting line at destination for delivery within switching limits, upon receipt of notice from connecting line it will notify the consignee and put such cars under constructive placement. (See Rule 4, Section C.)

Section B—When consignee desires a car delivered on a certain public track but carrier is unable to so deliver.

When delivery cannot be made on specially designated public-delivery tracks, on account of such tracks being fully occupied, or from other causes beyond the control of this railroad, notice shall be sent or given the consignee in writing or, in lieu thereof, as otherwise agreed to in writing, that delivery will be made at the nearest available point to the consignee, naming the point. Such delivery shall be made unless the consignee shall before delivery indicate

a preferred available point, in which case the preferred delivery will be made.

In the event consignee or party entitled to receive shipment serves notice upon this railroad of refusal to accept delivery at the point named in notice sent or given in accordance with Paragraph 1, the car will be held awaiting opportunity to deliver on the specially designated track and time will be computed on such cars from first 7:00 A. M. after the day the carrier notifies the consignee of its inability to deliver on the desired track.

Rule 6.—Cars for Loading.

The Constructive Placement Rule.

Section A—Cars held for loading will be considered placed when such cars are actually placed or held on orders of the consignor. In the latter case, the agent must send or give the consignor written notice of all cars which he has been unable to place because of the condition of the other-than-public-delivery track, or because of the other conditions attributable to the consignor. This will be considered constructive placement. (See Rule 3, Section D.)

Section B—When empty cars placed on orders are not used in transportation service, demurrage will be charged from the first 7:00 A. M. after actual or constructive placement until released, with no free time allowance.

Section C—Cars received from a switching line and held by this railroad for forwarding directions are subject to demurrage charges from the first 7:00 A. M. after they are received, until proper forwarding directions are furnished, with no free time allowance and without notice, except that cars received between 4:00 P. M. and 7:00 A. M. will not be subject to demurrage if forwarding directions are received prior to the following 12 noon.

Private cars which have been loaded on the tracks of their owners, received from such tracks and held by this railroad for forwarding directions, are subject to demurrage charges from the first 7:00 A. M. after they are received until proper forwarding directions are furnished, with no free time allowance and without notice.

Section D—If an empty car is appropriated without being ordered, it shall be considered as having been ordered and actually placed at the time so appropriated. If not loaded outbound, such car is subject to Section B of this rule.

Rule 7.—Demurrage Charges.

Section A—On cars not subject to Rule 8 (Average Agreement): After the expiration of free time allowed, the following charges per car per day, or fraction of a day, will be made until car is released:

For each of the first four days, $2.00;
For each succeeding day, $5.00.

Section B—The charges on cars subject to average agreement are set forth in Rule 8.

Note 1—When through no fault of the consignor or consignee the lading of a car is transferred by a carrier into two or more cars or when two small cars are furnished by a carrier in lieu of one large car ordered by the shipper, demurrage will be charged as for one car only, as long as any of such cars are detained beyond the free time.

Note 2—When a car contains two or more minimum carload shipments consigned to more than one consignee at the same station, demurrage will be charged the same as if the shipments had been received in separate cars and each consignee will be allowed a total free time of forty-eight hours (two days) for unloading, free of interference by the other consignee or consignees.

Rule 8.—Average Agreement Rule.

Your Advantage to Load and Unload Cars Promptly.

When the following agreement has been entered into, the charge for detention of cars, on all cars subject to demurrage, held for loading or unloading, shall be computed on the basis of the average time of detention to all such cars released during each calendar month; such average detention and charge to be computed as follows:

Section A—One credit will be allowed for each car, released within the first twenty-four (24) hours of free time. After the expiration of forty-eight (48) hours' free time, one debit per car per day, or fraction of a day, will

be charged for each of the first four days. In no case shall more than one credit be allowed on any one car, and in no case shall more than four credits be applied in cancellation of debits accruing on any one car. When a car has accrued four debits a charge of $5.00 per car per day, or fraction of a day, will be made for all subsequent detention and will apply on all subsequent Sundays and legal holidays, including a Sunday or holiday immediately following the day on which the fourth debit begins to run.

Section B—Credits earned on cars held for loading shall not be used in offsetting debits accruing on cars held for unloading, nor shall credits earned on cars held for unloading be used in offsetting debits accruing on cars held for loading.

Section C—Credits cannot be earned by private cars on the private tracks of their owners, but debits charged on such private cars while under "constructive" placement may be offset by credits earned on other cars.

Section D—At the end of the calendar month, the total number of credits will be deducted from the total number of debits and $2.00 per debit will be charged for the remainder. If the credits equal or exceed the debits no charge will be made for the detention of the cars and no payment will be made by this railroad on account of such excess of credits; nor shall the credits in excess of the debits of any one month be considered in computing the average detention for another month.

Section E—A party who enters into this agreement shall not be entitled to include under the plan cars subject to Rule 2-(b). (Cars on which there is only twenty-four hours' free time allowance), nor cars which the carrier has "bunched" unless the bunching was caused by a strike in which case, such cars may be included.

Section F — A party who enters into this average agreement may be required to give sufficient security to this railroad for the payment of balances against him at the end of each month.

Section G—An average agreement must include all cars loaded or unloaded within the jurisdiction of the same station, except that when desired, separate agreements may be entered into for each plant or yard within the jurisdiction of the same station, but in no case can the cars loaded or unloaded within the jurisdiction of two or more stations be combined in one average agreement, nor shall the cars loaded or unloaded by more than one consignor or consignee be combined in one average agreement, except that cars consigned, reconsigned, or ordered to a public elevator, warehouse or cotton compress serving various parties may be combined in one average agreement.

NOTE: No Demurrage charges may be properly collected for detention of cars through causes named below:

Rule 9.—Some Conditions Under Which Demurrage Does Not Accrue.

Weather Interference.

1. When the condition of the weather during any part of the free time period is such as to make it impossible for men or teams to work at loading or unloading, or impossible to place freight in cars or move it from cars without serious injury to the freight, or when, because of high water, or snow drifts, it is impossible during the free time period to get to the cars for loading or unloading, the free time will be extended until a total of forty-eight hours free from such interference shall have been allowed.

   The extra time allowed because of high water and snow drifts does not apply to cars on private tracks unless the railroad is at fault.

   No additional time will be allowed unless claim, stating fully the conditions which prevented loading or unloading within the free time, is presented in writing to the railroad's agent within thirty (30) days after the date on which the demurrage bill is rendered.

Frozen Shipments

2. When, at time of actual placement, lading is frozen so as to require heating, thawing or loosening to unload, the free time allowed shall be extended forty-eight (48) hours, making a total of ninety-six (96) hours' free time, provided the consignee shall, within forty-eight (48) hours after actual

placement, serve upon the railroad's agent a written statement that the lading was in such frozen condition at time of actual placement.

Bunching Cars.

1. Cars for Loading. When, by reason of delay or irregularity in filling orders, cars are bunched and placed for loading in accumulated numbers in excess of daily placing as ordered, the shipper shall be allowed such free time for loading as he would have been entitled to had the cars been placed for loading as ordered.
2. Cars for Unoading or Reconsigning. When, as the result of the act or neglect of any carrier, cars originating at the same point, moving via the same route and consigned to one consignee at one point, are bunched or when cars originating at different points and transported via the same route from an intermediate common point to destination are bunched after arriving at the common point (in which event the dates of arrival of the cars at common point will govern in determining the bunching instead of the dates of shipment), and are tendered for delivery by this railroad in accumulated number in excess of daily shipments, the consignee shall be allowed such free time as he would have been entitled to had the cars not been bunched, but when any car is released before the expiration of such free time on the next car will be computed from the first 7:00 A. M. following but when any car is released before the expiration of such free time, the free time on the next car will be computed from the first 7: A. M. following such release; provided, however, no allowance will be made unless claim is presented in writing to this railroad's agent within thirty days after the date on which bill for demurrage is renedered, supported by the receipted bill as evidence of payment of the demurrage as originally charged and a statement showing date and point of shipment of each car involved in the bunching claim.

NOTE: Under this rule, cars moving from different points and/or via different routes to destination and arriving on different dates will be considered bunched if tendered for delivery on one day and such free time shall be allowed as the consignee would have been entitled to, had the cars been placed or tendered for delivery in the order of their arrival.

Demand of Overcharge.

When the railroad agent demands the payment of transportation charges in excess of published tariff authority and cars are detained for this reason, no demurrage will be collected.

Delayed or Improper Notice.

1. (a) When notice of arrival does not contain all the information specified, consignee shall not have the right to call in question the sufficiency of such notice, unless within the prescribed free time he shall serve upon this railroad's agent a written statement of the omitted information required, in which event the time between receipt of such statement and the furnishing of the omitted information will not be computed against the consignee.

   (b) When the consignee makes request in writing for the name of the consignor, point of shipment and/or, if transferred in transit, the initials and number of the original car, to enable him to identify the shipment in a car placed or tendered for delivery on other-than-public-delivery track, such information will be furnished, but consignee shall not be entitled to additional free time unless such request has been served on this railroad's agent within the prescribed free time, in which event the time between receipt of the request and compliance therewith will not be computed against the consignee.

Errors of the Railroad.

Any error of the railroad which prevents proper tender or delivery of cars will exempt them from demurrage.

1. Under this Rule demurrage will be charged on the basis of the amount that would have accrued but for such error. This also applies in the case of constructively placed cars being "run-around" by actually placing recent arrivals ahead of previous arrivals, but allowance will only be made on cars subject to Rule 8, Average Agreement, that are held beyond the fourth debit day.

Diversion and Reconsignment Rules

Extracts, Digest and Application of the Uniform Diversion and Reconsignment Rules

The Rules Governing Diversion or Reconsignment of Carload Shipments, described below, are as published by the Baltimore & Ohio Railroad*, and are practically the same as are currently operated by all trunk lines, and most short line railroads of the United States.

NOTE: For a list of the services which the shipper may demand of the carrier in connection with a carload shipment which has already been delivered to the carrier with proper billing instructions, and which services contemplate a change of any sort from the original billing or service contracted for when the shipment had its inception, see "Definition" on the following page.

QUESTIONNAIRE

Under what conditions may the shipper demand diversion of a carload shipment? (See "CONDITIONS.")

For diversion or reconsignment services, which are accorded free of charge? (See "EXCEPTIONS.")

	See Rule No.
How will it affect the freight charges if a shipment is diverted in transit so as to move over a route via which the through rate is not applicable?	2
Suppose there is no joint through rate from point of origin to final destination of the shipment; may car be diverted, and if so, on what basis of freight rates?	2
If a car is ordered stopped in transit for further orders, and is held by the carrier pending such new instructions; how about Demurrage in the meantime?	3
May a car be reconsigned if the road-haul carrier has turned over to a switching line for delivery?	4-(A)
How about switching services involved when a car is reconsigned?	4-(b)
Suppose the carrier receives diversion instructions after it has delivered car to a connecting line, and it is now too late for the carrier receiving such instructions to divert, what is its duty?	4-(c)
How many times may the destination of a carload shipment be changed?	5-(a)
What happens when the shipper requests change in destination after car has already had one change?	5-(b)-5(c)
What is the charge for having the name of the shipper, as shown in the billing, changed?	6
May any other change in billing be made under the same charge?	6
Suppose it is desired to divert a shipment to a new destination and the carrier receives the order before arrival of car at first billed destination or terminal yard; what charge for making the change?	7
What is the reconsigning charge when a car is stopped in transit for orders?	8-(A)
Note that according to Rule 5, only one change in destination will be permitted under the through rate; suppose a car is stopped in transit for orders, and is later sent to a new destination. Is the shipper entitled to the through rate, or must he pay the sum of the locals as mentioned in Rule 5?	8-(a)
Suppose the car in the above case, instead of being stopped in transit, is, after arrival, withheld from delivery to consignee,	

*B. & O. Diversion or Reconsignment Tariff I. C. C. No. 18685, effective July 1, 1922.

NOTE: Suppose the reconsigning charges or rules are changed by the carrier before shipment is reconsigned, but after it leaves original shipping point; what effect do such changes have upon the rights of the shipper as to such shipments?

ANSWER: The rates, rules, charges, privileges and regulations in effect when the shipment was first delivered to the carrier will apply on that shipment until it reaches its ultimate destination. (See "In the Matter of Through Routes and Through Rates," 12 I. C. C. 163; and "In Re Milling-In-Transit Rates," 17 I. C. C. 113.)

DIVERSION OF RECONSIGNMENT RULES

Definition.

For the purpose of applying these rules, the term "Diversion" or "Reconsignment" means:

(a) A change in the name of the consignee.
(b) A change in the name of the consignor. (See Rule 6.)
(c) A change in destination. (See Rule 5.)
(d) A change in route at the request of the consignor, consignee or owner.
(e) Any other instructions given by consignor, consignee, or owner, necessary to effect delivery which require a change in billing or an additional movement of the car, or both. (See Section 2 of Exceptions.)

Application.

Freight in carloads, except as provided below, may be diverted or reconsigned on these lines, subject to the rules provided herein.

If request is made for the diversion or reconsignment of freight in carloads, these lines will make diligent effort to locate the shipment and effect diversion or reconsignment, but will not be responsible for failure to effect the diversion or reconsignment desired unless such failure is due to the negligence of their employees.

The term "Switching Limits," as used in these rules, means all locations within the recognized switching of all carriers serving the billed destination, and not merely the switching limits of the carriers receiving the road-haul movement.

Conditions.

The services herein authorized are subject to the following conditions:

(a) That shipments have not broken bulk;

(b) Orders for diversion or reconsignment will not be accepted under these rules at or to a station or to a point of delivery against which an embargo is in force. Shipments made under authorized permits are not subject to this condition;

(c) On straight consignments the original bill of lading should be surrendered or other proof of ownership established. On shipments consigned "to order," original bill of lading should be surrendered for endorsement or exchange or in its absence satisfactory bond of indemnity executed in lieu thereof, or other approved security given at the time the diversion or reconsignment order is placed;

(d) Request for diversion or reconsignment must be made or confirmed in writing.

(e) **Prepayment or Guarantee of Charges.** All charges accruing under these rules must be prepaid or guaranteed to the satisfaction of the carrier by the person or persons requesting the diversion or reconsignment or re-forwarding before shipments are forwarded.

Exceptions.

The Reconsigning or Diversion Rules and Charges, named herein will not apply to the following services:

Section 1—For a single diversion or reconsignment if order for such diversion or reconsignment is received at initial billing point, provided the change involves no extra movement of the car.

Section 2—Where a car is placed for delivery at destination, and an order for the delivery of the contents thereof to other than the billed consignee is or has been presented to and accepted by the agent of these companies at destination, and no change is involved in billing records, nor additional movement of car is required.

Section 3—Where a change in route is made necessary by embargo placed against the billed destination or route thereto subsequent to acceptance of the shipment by carrier at point of origin.

No charge will be made for services mentioned above in Sections 1, 2 and 3.

RULES AND CHARGES

Rule 1.—Transfers and Waybills.

Transfers and Waybills covering shipments which have been diverted or reconsigned under these rules should bear separate notation stating where and when the diversion or reconsignment was effected, and charges, if any, were made.

Rule 2.—Freight Rate Applicable.

These rules and charges will apply whether shipments are handled at local rates, joint rates, or combination of intermediate rates. The through rate to be applied under these rules is the rate from point of origin via the diversion, reconsigning or forwarding point to final destination in effect on date of shipment from point of origin. If the rate from original point of shipment to final destination is not applicable through the point at which the car is diverted, reconsigned or reforwarded, in connection with this line, the tariff rates in effect to and from the diversion, reconsigning or reforwarding point will apply, plus diversion or reconsigning charges.

Rule 3.—Demurrage and Track Storage.

Freight stopped, diverted, reconsigned or reforwarded under these rules will, in addition, be subject to demurrage and track storage charges lawfully in effect at point where stopping, diversion, reconsignment or reforwarding is accomplished. (See Rule 2-B of the article on Demurrage Rules.)

Rule 4.—Application and Scope of Rules.

(a) **Application:** The rules published herein, governing the diversion or reconsignment of freight, are applicable while the freight is in possession of these lines, also when it has reached billed destination on these lines and has been delivered to switching road for placement.

(b) **Switching Charges Additional:** If diversion or reconsignment is made after arrival of car at billed destination and the car has been delivered to a connecting road, all switching charges of connecting road will be in addition to any other charge named herein.

(c) **Diversions or Reconsignments Beyond Rails of these Lines:** When diversion or reconsignment is requested after shipment has passed out of possession of these lines, or when request is received too late for these lines to effect the change desired, such request will be transmitted to direct connecting carrier to which shipment was delivered, when the responsibility of these lines will end; and the shipment will be subject to rules of the carrier on whose rails the diversion or reconsignment is accomplished. (Except as per Section (a) of this rule.)

Rule 5.—Only One Change in Destination.

(a) Only one Change in Destination will be permitted by these lines under these rules, except as provided in Section (b), and then only provided the car has not had a previous change in destination after leaving the initial billing point.

(b) If the consignor, consignee or owner requests a subsequent change necessitating movement of the car, the shipment will be treated as a reshipment from point of reforwarding and will be charged at the tariff rate therefrom, plus *$6.30 per car.

(c) If a car is stopped short of billed destination after it has had one diversion or reconsignment under these rules, charges will be made on basis of the tariff rates to and from the point at which the first diversion or reconsignment was accomplished, plus *$6.30 per car in addition to the other diversion or reconsignment charges previously accrued.

Rule 6.—Change in Name of Consignor.

The charge for a change in the name of consignor with no further change in billing instructions, will be *$1.35 per car, except as provided in Exceptions, Section 1.

Rule 7.—Diversion or Re-Consignment in Transit.

If a car is diverted or reconsigned in transit prior to arrival at original destination, or if the original destination is served by a terminal yard, then prior to arrival at such terminal yard, a charge of *$2.70 per car will be made for such service.

Rule 8.—Stopping in Transit.

(a) If a car is stopped for orders for the purpose of delivery or diversion or reconsignment or reforwarding prior to the arrival at such terminal yard, on request of consignor, consignee, or owner, a charge of *$2.70 per car will be made for such service and the point where the car is stopped will be considered the destination of the freight. If the car is subsequently forwarded from point at which held, the provisions of Rules 9, 10, 11 or 12, as the case may be, will also be applied. The service of stopping as provided in this rule will not prevent one change of destination under the provisions of Rule 5.

(b) If after arrival at destination, or if such destination is served by a terminal yard, a car is withheld from placement, on request of consignor, consignee, or owner, no charge will be made for such service, but the point at which held will be considered the destination of the freight and the party upon whose order car is held will be notified at the Post Office address designated by him. If the car is subsequently placed for unloading or is reforwarded from the point at which held, the provisions of Rules 9, 10, 11, 12 and 13, as the case may be, will also be applied. The service of withholding from placement as provided in this rule will not prevent a change of destination under the provisions of Rule 5, nor prevent a diversion or reconsignment under the provisions of Rule 11.

Rule 9.—Changed at Destination on Orders Given Before Arrival.

If order for diversion or reconsignment is placed with local freight agent at billed destination or other designated officer, in time to permit instructions being given to yard employes prior to arrival at such billed destination, or if the original destination is served by a terminal yard, then prior to arrival at such terminal yard, a charge of *$2.70 per car will be made for such service.

Rule 10.—Diversion or Reconsignment to Points Outside Switching Limits Before Placement.

If a car is diverted, reconsigned or reforwarded on orders placed with local freight agent or other designated officer after arrival of car at original destination, but before placement for unloading, or if the original destination is served by a terminal yard, then after arrival at such terminal yard, a charge of *$6.30 will be made if car is diverted, reconsigned or reforwarded to a point outside of switching limits of original destination.

Rule 11.—Diversion or Reconsignment to Points Within Switching Limits Before Placement.

A single change in the name of consignee at destination and/or a single change in or a single addition to the designation of his place of delivery at destination will be allowed.

(a) Without charge, if order is received in time to permit instructions to be given yard employes prior to arrival of car at destination, or if the destination is served by a terminal yard, then prior to arrival at such terminal yard.

(b) At a charge of *$2.70 per car if such orders are received in time to permit instructions to be given to yard employes within twenty-four (24) hours after arrival of car at destination, or if the destination is served by a terminal yard, then within twenty-four (24) hours after arrival at such terminal yard. (See Note.)

(c) At a charge of *$6.30 per car if such orders are received subsequent to twenty-four (24) hours after arrival of the car at destination, or if the destination is served by a terminal yard, then subsequent to twenty-four (24) hours after arrival at such terminal yard. (See Note.)

NOTE: In computing time, Sundays and legal holidays (national, state and municipal) will be excluded. (When a legal holiday falls on Sunday, the following Monday will be excluded.)

Rule 12.—Diversion or Reconsignment to Points Outside Switching Limits After Placement.

If a car has been placed for unloading at original billed destination and reforwarded therefrom without being unloaded to a point outside of the switching limits, it will be subject to the published rates to and from the points of reconsignment, plus *$6.30 per car reconsignment charge, except that in no case shall the total charge be less than the charge based on the through rate from point of origin to final destination, plus *$6.30 per car reconsignment charge.

NOTE: If a car has been placed for unloading on a public delivery track, but has not been unloaded or accepted by consignee or owner, it will be subject to Rule 10.

Rule 13.—Diversion or Reconsignment to Points Within Switching Limits After Placement.

Cars that have been placed for unloading and which are subsequently reforwarded without being unloaded to a point within the switching limits of but will be subject to the switching or local rate in addition to the rate from the billed destination will not be subject to diversion or reconsignment charge, point of origin to billed destination.

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*Charge varies in Eastern, Western and Southern territories.

Tests of Road-Building Rock.

The Bureau of Public Roads has made at various times a large number of tests of road-building rock in the different states. These tests were published in Bulletin No. 370 of the Bureau, giving each individual test in detail. From this bulletin the following table has been made, giving averages by states of the principal kinds of rock. The number of samples averaged is given in each case. These averages are fairly representative, although in some of the groups there was a rather wide variation in the individual figures.

	No. of samples Tested.	Weight per cubic foot. Lbs.	Absorption per cubic foot. Lbs.	Per cent of wear.	French coefficient of wear.	Hardness.	Toughness.	Cementing value.
Alabama—								
Limestone	12	164	1.62	6.1	8	14.5	7	51
Dolomite	1	168	1.24	5.7	7.1			
Slag	3	161	1.53	9.2	4.4	14.9	6	122
Arizona—								
Limestone	1	168	0.41	5.3	7.6	18.1	6	43
Arkansas—								
Quartzite	1	165	0.54	2.7	14.8	19	22	8
California—								
Chert	6	169	.29	12.4	4.4	19.3	8	65
Granite	6	163	.96	9.8	8.9	18.6	15	53
Limestone	8	163	2.19	3.8	11.3	14.4	9	198
Volcanic breccia	1	137	8.79	8.8	4.5	12.2	3	500
Colorado—								
Limestone	3	158	3.96	6.1	6.8	3.	7	66
Slag	1	215	.25	4.3	9.3			47
Connecticut—								
Diabase	22	182	.77	2.3	19.2	17.7	21	136
Florida—								
Silicious limestone	1	155	6.93	17.6	2.3	12		230
Shell limestone	1	153	3.17	13.1	3.0	12.3	6	65
Weathered chert	1	143	.30	10.9	3.7	18.8	13	10
Georgia—								
Granite	21	165	.40	4.7	9.2	18.5	6	14
Limestone	6	170	.74	4.3	9.6	16.0	8	46
Biotite Gneiss	32	169	.45	5.6	7.8	17.9	7	21
Idaho—								
Basalt	6	173	1.98	4.9	10.3	14.8	14	169
Illinois—								
Limestone	31	166	1.28	5.1	8.2	14.0	7	44
Slag	5	186	.48	10.2	5.6	16.2	9	44
Dolomite	30	167	1.89	5.8	7.1	13.7	7	33
Indiana—								
Limestone	40	166	1.37	4.8	8.7	13.6	8	54
Kansas—								
Limestone	7	157	3.24	8.5	5.4	12.6	5	35
Kentucky—								
Limestone	6	168	.79	4.7	9.1	15.4	7	44
Louisiana—								
Ferruginous limestone	1	153	3.65	30.3	1.3	14.7	2	76
Quartzite	1	147	1.53	3.8	10.5	15.3	8	25
Maine—								
Granite	10	163	.72	4.0	10.6	18.9	9	19
Biotite Gneiss	5	170	.50	6.7	6.6	17.7	7	48
Maryland—								
Diabase	6	188	.32	1.8	23.5	18.6	31	32
Limestone	7	172	.31	4.5	9.5	15.2	9	45
Granite	6	166	.55	3.1	14.0	18.6	10	16
Massachusetts—								
Biotite granite	5	165	.21	3.7	10.7	18.8	10	13
Michigan—								
Dolomite	9	167	1.79	4.7	8.7	13.8	7	25
Limestone	20	165	1.48	5.0	8.5	13.4	9	44
Minnesota—								
Slate	2	174	.60	4.9	10.5	12.0	8	59
Quartzite	2	165	.27	1.9	21.8	19.3	17	27
Ferruginous sandstone	2	164	.90	8.1	6.5	14.8	10	9
Mississippi—								
Sandstone	5	151	3.83	13.1	4.2	16.7	7	112
Missouri—								
Limestone	20	165	1.17	6.2	7.5	11.8	6	44
Montana—								
Calcareous sandstone	2	163	1.41	3.5	11.2	16.9	13	140

	No. of samples Tested.	Weight per cubic foot. Lbs.	Absorption per cubic foot. Lbs.	Per cent of wear.	French coefficient of wear.	Hardness.	Toughness.	Cementing value.
Nebraska—								
Limestone.	9	159	2.68	5.5	7.7	11.9	6	65
New Hampshire—								
Granite.	5	165	.41	3.7	10.9	18.2	10	21
New Jersey—								
Basalt.	10	186	.93	3.0	34.9	23.3	36	296
Dolomite.	3	178	.30	3.6	11.3	13.1	13	34
New York—								
Limestone.	20	170	.71	3.8	11.5	15.4	10	52
Calcareous sandstone.	7	174	.67	3.7	11.3	17.8	16	48
North Carolina—								
Granite.	10	165	.34	3.7	11.9	18.6	9	17
Marble.	3	172	.16	5.0	8.1	14.3	4	35
Biotite Gneiss.	10	182	.37	6.4	9.3	16.2	9	31
Ohio—								
Calcareous sandstone.	4	158	3.38	13.5	5.9	6.9	7	48
Dolomite.	25	168	1.46	5.5	8.9	14.6	10	33
Limestone.	30	168	1.26	5.1	8.2	13.4	8	66
Oklahoma—								
Chert.	2	157	1.78	4.5	10.6	19.0	15	20
Limestone.	13	163	1.46	5.2	8.2	8.4	7	39
Oregon—								
Basalt.	7	171	1.81	3.8	13.1	17.2	23	58
Pennsylvania—								
Limestone.	40	168	.49	4.3	9.8	15.8	10	45
Slag.	9	167	2.89	8.7	6.6	15.8	8	53
Sandstone	26	163	1.61	3.8	12.7	15.7	14	59
Slate.	9	172	.51	3.4	14.1	15.8	24	46
Marble.	11	171	.24	4.8	8.6	13.3	6	40
Rhode Island—								
Granite.	6	166	.45	3.2	13.7	17.9	10	27
South Carolina—								
Granite.	8	167	.35	3.9	11.4	18.1	11	17
Tennessee—								
Limestone.	18	167	.76	4.8	8.8	14.5	6	53
Texas—								
Limestone.	20	163	1.57	6.4	7.5	12.4	6	52
Sandstone.	4	147	3.44	6.2	7.7	13.1	9	36
Utah—								
Limestone.	3	164	1.38	3.4	12.1	17.2	14	176
Vermont—								
Limestone.	3	171	.54	3.7	11.1	15.1	7	42
Dolomite.	6	177	.47	4.1	9.9	16.1	8	21
Quartzite	2	165	.22	4.5	11.5	19.2	8	3
Virginia—								
Amphibolite.	9	189	.65	3.6	15.9	17.1	12	69
Gneiss.	9	171	.35	5.6	8.5	17.8	9	25
Hornblende schist	13	190	.51	4.8	10.3	15.6	11	24
Granite.	14	165	.46	4.1	11.	18.3	12	25
Dolomite.	24	176	.52	4.1	10.7	16.4	11	36
Sandstone.	4	163	1.21	5.2	8.3	17.8	7	57
Limestone.	25	169	.36	4.5	9.2	15.9	8	35
Washington—								
Basalt.	30	176	.45	2.7	15.8	17.6	18	38
Diabase.	2	177	.35	3.3	12.3	17.2	14	140
Marble.	5	169	.54	5.1	7.9	12.7	6	23
Limestone.	2	172	.36	4.7	10.2	18.	12	90
West Virginia—								
Sandstone.	25	159	2.45	6.5	8.2	12.1	7	39
Limestone.	32	168	.56	4.2	9.8	16.	9	52
Dolomite.	4	173	1.08	3.3	12.3	16.5	12	61
Wisconsin—								
Dolomite.	40	170	1.45	6.1	7.4	14.4	7	35
Limestone.	3	165	1.74	4.4	9.2	15.	8	16
Sandstone.	7	157	.80	4.7	10.2	17.8	9	9
Granite.	5	164	.60	1.6	26.6	18.8	24	6

History of the Year 1922

January.

January figured among producers in the pit and quarry industries as a month of conventions. Many local gatherings were held in all parts of the country, and during this month also were held at Chicago, the annual Convention of the National Crushed Stone Association, and the American Good Roads Show, both of which were successful and contributed in no small way to the advance of road building and stone production.

During January the Mississippi Valley Conference of State Highway Departments adopted resolutions on the purchase of Portland cement, which practically boycotted that material, the idea ostensibly being to force down the price of cement from what was called by the Conference an exhorbitant figure.

An event of considerable interest during the month was the Road School for Indiana Highway Superintendents, held at Purdue University, Lafayette, Indiana. There, for one week, superintendents who were to take care of the building of Indiana's roads for the next year were schooled by expert engineers in some of the finer points of road construction. They were also given an opportunity to learn more of the production of sand, stone, gravel and cement from producers of these materials, who spoke at various sessions.

In January the Government reported that the exact center of population in the United States, so far as mines and quarries were concerned, is about ten miles south of the City of Springfield, Illinois.

Prices of sand and gravel declined in the East, while crushed stone in this section did not experience any price fluctuation. Portland cement dropped off a little, as did plaster. Common lime and finished materials remained about stationary.

The open winter in many sections of the country helped producers considerably, keeping markets active to a later date and making it unnecessary to shut down the plants as early as usual. Extensive housing movements began about this time and added considerably to the bright prospects for 1922.

The Iowa Sand and Gravel Producers Association decided that it had grown sufficiently in size to afford to retain a paid secretary, who would devote all his time to affairs of the Association.

It was announced in January the year of 1921 had been established as the best that the Portland cement industry had ever seen.

The Government announced that the total Federal Aid road appropriation to date, totaled $339,875,000.

Jan. 1. Texas motor truck law effective.

Jan. 3. Government mine safety car begins two-month tour of Wisconsin quarries at Wausau.

Jan. 4. Hearing before Iowa Board of Railroad Commissioners at Des Moines on commodity rates on "minimum carload weight on stone and articles taking same rates."

Jan. 4, 5. Annual meeting of Iowa Sand & Gravel Producers Association at Des Moines.

Jan. 9. Hearing on general freight reduction start before the Interstate Commerce Commission.

Jan. 10, 11. Annual meeting of the National Agricultural Limestone Association at Columbus.

Annual convention of Indiana Sand & Gravel Producers Association at Indianapolis.

Jan. 11. Annual meeting of the American Sand Association at Cleveland.

Jan. 12. Michigan Public Utilities Commission hears Michigan Sand & Gravel Producers Association on rate case at Lansing.

Jan. 16, 17, 18. Annual Convention National Crushed Stone Association begins in Chicago.

Jan. 16, 17, 18. Hearing at Washington on National Association Sand & Gravel Producers' petition for reduced rates.

Jan. 17, 18, 19, 20. American Good Roads Congress at Chicago.

Jan. 20. Mississippi Valley conference of state highways departments adopt resolutions practically boycotting cement.

Jan. 23-28. Highway Superintendents' Road School at Purdue University, Lafayette, Ind.

Jan. 25. Resumption of gravel hearing at Washington.

Jan. 28. I. C. C. hearing at Washington on reduction in freight rates on agricultural limestone.

Annual meeting directors National Slag Association at Cleveland.

February.

The annual convention of the National Association of Sand and Gravel Producers was held in New Orleans

on February 1, 2 and 3. A few days after this convention the Association filed with the Interstate Commerce Commission a brief of that celebrated rate case which attracted so much attention.

At the Pacific Experiment Station in Berkeley, California, the United States Bureau of Mines and the Northwest Magnesium Company did some co-operative work on the testing of caustic magnesia—an investigation of its properties in relation to Sorrel cement. Practical good came from the tests in that high grade caustic magnesia can be made from certain varieties of magnesite, hitherto considered unsuitable for the purpose.

The severe winter weather in Eastern cement districts during the early part of February had the effect not only of setting back operations in some of the mills, but of curtailing shipments far below normal times.

Kentucky put on a hard drive to get the State Legislature to pass a bill submitting to the public at he 1922 election, the question of issuing $50,000,000 worth of bonds for road building.

With the strong tone of the general building material market, sand, gravel and crushed stone, maintained prevailing price levels in the East. Indications pointed to an important building year much road work and considerable building construction. In Philadelphia alone, more than $2,000,000 was appropriated for paving city streets. There was a variable decline of five cents per cubic yard in the New York wholesale market. Portland cement held steady. The lime market was dull.

At a meeting of the Executive Committee of the Indiana Sand and Gravel Producers Association on February 10th, there was outlined a program for the year, which included the compilation of a freight rate tabulation, the extension of testing work to include more field tests and a publicity program and a Legislative program.

At the explosives chemical laboratory of the United States Bureau of Mines, at Pittsburgh, Pa., government experts began a study of TNT to determine its possibilities in the pit and quarry and mining industries. Considerable new and valuable information about explosives has been devoloped in this laboratory.

Feb. 1, 2, 3. Annual Convention National Association of Sand and Gravel Producers begins at New Orleans.

Feb. 7. National Association Sand and Gravel Producers files brief of reduced rate case with I. C. C.

Feb. 13, 14, 15, 16. Annual Convention American Concrete Institute at Cleveland.

Feb. 20. At insistence of Texas R. R. Commission most of carriers reduce rates on road building material.

Feb. 24. Joint meeting of Illinois Concrete Aggregate Association and Wisconsin Mineral Aggregate Association at Milwaukee.

Dynamite explosion at McCook Quarry of Consumers Company does $1,000,000 damage.

Feb. 27. Supreme Court upholds power of I. C. C. to regulate intrastate rates where discrimination against interstate traffic was shown to exist.

March.

Road building in Wisconsin began again when A. R. Hirst, the chief engineer of the Wisconsin Highway Commission, decided to break the so-called "cement boycott." Mr. Hirst's contention was that good roads, built as soon as possible, were much to be preferred to waiting for a possible small drop in the price of cement.

That the rate case begun by the National Association of Sand and Gravel Producers be dismissed, was the recommendation of Examiner Howard Hosmer. He advanced the opinion that charges in the Central Territory were not unreasonable.

Cement production was reported as on the increase in the Lehigh Valley section. This report was fairly typical of others from all over the country.

The report of the Bureau of Mines, issued during this month showed that 80 to 90 per cent of the soapstone quarried in the United States is waste. This waste material has not been generally utilized, but it may be feasible to grind it and produce a substitute for low grade talc.

On March 16th. members of the Illinois Concrete Aggregate Association met at Springfield, Ill. There was profitable discussion on compensation insurance, the operation of the lien law, the filing of personal bonds by highway contractors, railroad rates and other topics of interest. The meetings also served as a means of getting the producers in closer touch

with Mr. Sheets, Illinois State Highway Superintendent, who was present. There was in addition, discussion on methods of paying dues, consideration of the relations of the Illinois Concrete Aggregate Association to the National Association, also talk on open specifications.

There was a quickening aspect in the sand and gravel markets of the East, and the anticipation of good spring trade. Broken stone and affiliated rock materials also stood in favor for productive activities. Lime and other kindred specialties were in firm demand. The building industry in New York and vicinity reached a high point of operation, with about three-fourths of the activities devoted to dwellings and apartments.

According to Lawrence Lyons, Director of the Indiana State Highway Commission, the general spring condition of state roads constructed of such native materials as crushed stone and gravel, was excellent through Indiana. An inspection was made as soon as winter conditions were over.

Texas gravel dealers complained of disadvantages under which they labored as a result of the new state highway law effective at the beginning of 1922, which imposed a graduated license fee on motor trucks, depending on the load. This law falls especially hard upon low value deadweight hauls. Several dealers took steps to get test cases under way.

Gravel production in the vicinity of Dallas was at capacity and many operations in Dallas and other Texas cities were steadily improving.

In spite of water handicaps, the spring season opened well in Louisville, and a continued good trade was expected. Diggers were set to work in the river rather earlier than usual.

Fluorspar shipped from mines in the United States in 1921, according to Hubert W. Davis of the United States Geological Survey, amounted to approximately 35,600 short tons, valued at $708,000, a decrease of 81 per cent in quantity and of 85 per cent in value as compared with 1920.

Mar. 1. Hearing on Iowa Intrastate rates by State R. R. Commission at Des Moines.
Mar. 8. Wisconsin breaks cement boycott.
Mar. 9. Capt. Daniel Donnelly of Cincinnati, "the Gravel King," dies at age of 78.
Mar. 15. Iowa Sand and Gravel Producers Association meet at Mason City.
Mar. 16. Illinois Concrete Aggregate Association meeting at Springfield.

April.

When the case against the cement manufacturers came up in New York the early part of April, for violation of the Sherman Anti-Trust Law, the opening statement for the defendants was made by Mr. Henry M. Stimson, who clearly set forth the position of the manufacturers.

The Ohio Sand and Gravel Producers Association held their annual meeting at Columbus on Tuesday, April 13th. The most important action taken at this meeting was the withdrawal of the Ohio Association from the National Association, effective the first of July, 1922. Annual dues were reduced from 4 mills to 2 mills per ton.

The outstanding feature of the program of the National Construction Conference, held in Chicago on April 3, 4 and 5, was an address by Herbert S. Hoover, Secretary of Commerce, in which he defined the limits within which trade associations can properly operate. Mr. Hoover commended all efforts that have been made toward simplification and standardization and declared against restraint in organized labor against "fixed" prices and other practices that are working harm to the industries of the country.

All records for building operation were broken in Louisville in March and April. High water on the river bothered some of the producers a little but on the whole they got along very well.

The United States Geological Survey published during this month figures on production of Portland cement in 1921, giving for each of the districts the quantity produced, stocks at the end of the year, quantity, value, and average factory price of material shipped. The total shipment in 1921, about 95,051,000 barrels, were nearly 99 per cent of those in 1920.

The favorable conditions under which the season opened in the East continued and producers were in good position to supply material with market stability of growing strength.

Oliver Bowles, mineral technologist of the United States Bureau of Mines,

issued a paper on the standardization of the numerous products of the various non-metallic industries.

A suit filed against the Bedford Stone Corporation Auxiliary, Inc., charged existence in Indiana of an unlawful combination of companies which controlled the quarrying and sale of Indiana limestone, and asked for a permanent injunction preventing the continuance of the alleged "combination and conspiracy."

Sand and gravel plants in various parts of Maryland resumed operations on a heavy production schedule. Crushed stone plants also showed equal keenness to advance outputs, inspired by the heavy orders looming ahead for road construction.

Production and demand reached a satisfying point in the Pittsburgh district with the various producers in good position to increase operations to the necessary status.

The high stage of the Mississippi river during April occasioned some little interruption to sand and gravel producers.

There was a brisk demand for materials around Memphis, despite a very rainy season that retarded work to some extent. In general much road and street work caused a good demand. Permits for 1922 doubled those for 1921.

R. C. Yeomans, secretary-engineer of the Indiana Sand and Gravel Producers Association, made a good case for gravel roads when he showed that the only Indiana gravel roads not in the best of shape were those in which heavy pebbles were lacking.

Apr. 3, 4, 5. National Construction Conference at Chicago.
Apr. 12. National Agstone Association meet in Columbus, Ohio.
Apr. 13. Ohio Sand and Gravel Producers meet at Columbus, Ohio.
Apr. 22. Eleven days of American Building Exposition begins at Cleveland.
Apr. 27. Indiana Limestone Quarrymen's Association meets at Indianapolis.

May.

Figures compiled by the Bureau of Mines showed that mineral products constituted about 56 per cent of the total railroad tonnage from all sources.

Another cheerful report from the United States Geological Survey showed that during 1921 crushed stone production gained 8 per cent, while the stone industry as a whole decreased 20 per cent. This in spite of the fact that certain outlets have been narrowed down, as for example, the metal industries, where depression has led to a decrease of 50 per cent in the amount of stone used for fluxing and refractory purposes.

The Executive Committee of the National Crushed Stone Association met in New York City on May 1st. The Research Committee covered extensively the subject of screenings, giving accounts of experiences where these screenings have been washed and sold at a profit, and of instances in which the stone, when of proper chemical constitution, has been disposed of for agstone purposes. The meeting went on record as favoring a loading leeway of 10 per cent below marked capacities of railroad cars to 10 per cent above capacities.

Returns from the United States Geological Survey showed a phosphate rock production considerably lower than 1920. Another report on limestones and pulpstones showed a decrease of 50 per cent from the 1920 output in quantity and a 28 per cent decrease in value.

Reports from manufacturers of explosives showed that their sales for March, 1922, ran 10.9 per cent above March, 1921. Of the total sales in March, 12.3 per cent were permissible explosives as compared with 10.3 per cent for March, 1921.

During the month there was a marked increase in sand and gravel production in the Pittsburgh district with corresponding advance in demand.

The United States Geological Survey announced the finding of extensive deposits of potash in Reagan County, Texas. Announcement was also made that the output of calcareous marl in the United States decreased in value during 1921 about 45 per cent. Nearly all of this marl is used for liming the soil.

There was a literal boom in cement production in the Lehigh Valley section. Orders piled up well in advance of shipments, insuring operation of the peak conditions for some time to come.

The passage of the Dunn Aid Road Bill provoked a great storm of disapproval from good roads advocates generally. The bill authorized the ap-

propriation of $65,000,000 for the year beginning July 1st, and an appropriation of $75,000,000 for the year thereafter.

The first inconveniences of the general car shortage began to be felt during this month.

Producers in the East found business very good. Overtime work prevailed at a number of the plants and large shipments were made. Orders in many places were in excess of demands. Prices of aggregates remained firm while Portland cement advanced. Lime prices remained stationary.

The sun of prosperity shone brightly in Kentucky. Building operations demanded much in the way of materials.

To show the extent of the Portland cement industry and the complexity of cement plant operation, the manufacturers indicted in New York for combining in restraint of trade introduced motion pictures to illustrate the steps from the quarrying to the finished product. Many prominent figures in the construction world gave testimony favorable to the case of the cement manufacturers.

Mr. W. R. Phillips took up the duties of secretary and general manager of the National Lime Association on May 16th.

May 1. Executive Committee National Crushed Stone Association meets in New York City.

U. S. Geological Survey announces discovery of large deposits of potash in Texas.

May 15. New distance scale of building rates by South Dakota Board of R. R. Commission goes into effect.

May 16. 50,000 bbls. marks biggest day in cement shipments from Lehigh Valley District.

Mr. W. R. Phillips takes up duties of secretary and general manager of the National Lime Association.

May 22. Oral argument on National Gravel Association case.

May 24. National Agstone Association meets at Marion, Ohio.

June.

By acquiring a large interest in and assuming the management of the American Lime Stone Company, the Charles Warner Company of Wilmington, Delaware, became the largest producers of burned lime products for all purposes in the United States, with a capacity exceeding 300,000 tons per year.

On June 14, 15 and 16, over 100 lime producers of the United States, attended the Fourth Annual Convention at Cleveland. The chief thing that this Convention emphasized was the technical advance of the lime industry.

The Bureau of Public Roads estimated that a system of highways that would serve the whole country and which would be far superior to any other in the world, will comprise some 180,000 miles of road.

The sand, gravel and crushed stone markets continued active in New York and vicinity with a good call for materials and a marked firmness in prices.

The Michigan Public Utilities Commission handed down a decision on the action brought by the Michigan Sand and Gravel Producers Association. This decision had the effect of reducing the Michigan mileage scale an average of 17 per cent, also of reducing the carload weight from 100 per cent to 90 per cent of the car. Taken in connection with the reduction ordered into effect a year ago, this order reduced the rates on sand and gravel in Michigan to, or below, the rates in effect prior to the increase of August 26th, 1920. This was one of the best decisions from the standpoint of the producer, rendered throughout the country by any State Public Utility Commission.

The Bureau of Mines began general research, in conjunction with the National Foundrymen's Association and the National Research Coucil, on the subject of sands for molds and cores employed in aluminum-alloy foundry practice.

All the large sand and gravel companies in the Pittsburgh district maintained active production.

The building boom in Louisville compared favorably with cities two or three times its size, and material producers profited accordingly. There was also an ease in freight rates and the state as a whole prospered unusually because of the coal strike in other states, while the Kentucky mines were going full. The only fly in the ointment was some fear of railway strike troubles.

The output of fuller's earth in the United States in 1921 showed a decrease of 19 per cent as compared with 1920. During 1921 it was mined only in Alabama, Florida, Georgia,

Massachusetts, and Texas. It is found in many other states.

June 1. Chas. Warner Company and American Lime & Stone Company merge.
June 3. Cement placed on free list.
June 13. National Slate Association meets at Philadelphia.
June 14, 15, 16. Annual Convention of National Lime Association at Cleveland.
June 27, 28. Portland Cement Association meets at Atlantic City.

July

The erection, by the state of South Dakota, of a state owned plant for the production of Portland cement, raised quite a storm of protest in that section of the country. The building of the plant was strongly opposed by Governor MacMaster.

The Trunk Line Association granted the request of the National Sand & Gravel Producers Association to reduce minimum car load weights on sand and gravel to the basis of 90 per cent of the marked capacity of the car, instead of the full basis of marked capacity as heretofore, the new arrangement to become effective in September. Similar applications had been filed with the Western Trunk Line Committee at Chicago and the Southwestern Freight Bureau at St. Louis.

The program of the National Forest Highway Construction, involving the outlay of approximately $10,000,000 for 1170 miles of road in 23 states, was approved by Secretary of Agriculture Wallace, the program to be financed largely from the forest highway fund, provided by the Federal Highway Act.

Announcement was made that the construction and maintenance of highways, motor roads and truck channels during 1922, would total in round numbers about $680,000,000, about $53,000,000 more than 1921, federal aid accounting for about $125,000,000.

Experiments made with liquid oxygen as an explosive by an American metal mining company at Pachuca, Mexico, gave quite satisfactory results, according to observations made by a representative of the United States Bureau of Mines. The development of this invention so far has been carried on largely in Germany, and has there made considerable advance. The only extensive development outside of Germany has been in the Lorraine iron mines where the Germans installed apparatus. One company in Lorraine is mining its entire annual output of 1,500,000 tons of iron ore by the use of this explosive.

A continuance of construction operations in buildings and roads, developed strong activity in the eastern sand, gravel and crushed stone markets. Prospective buyers were numerous and were constantly on the lookout for first grade stocks. Distribution kept pace with sales, and large tonnages reached all active sections of the New York and New Jersey districts. Labor was not very abundant, but producers did not have much difficulty on this score. Prices held firm with no indication of recession.

Operations in the Lehigh Valley cement district continued under peak conditions, with all mills on the producing list. The coal situation gave some concern, but no great amount of trouble was experienced in getting railroad cars.

The sand and gravel markets of Pittsburgh showed no curtailment in activity, and producers continued operating at a good status. Large quantities of material reached the local port for nearby points, and found ready sale.

Busy times in road building and the general construction boom in Louisville contributed to good times in that city. Operators worked steadily and reported a very satisfactory outlook.

The Government reports on the production of fuller's earth, showed that activity in this industry was not so great during 1921 as during 1920. The decline was 18 per cent in output and 21 per cent in value. The demand increased later in 1921, however, and 1922 figures, when available, will undoubtedly show up very favorably.

Announcement was made by the United States Geological Survey that a massive deposit of magnesite of unusual character that was recently brought to the attention of the Survey, promises to yield a large readily available supply of this material. The deposit lies in Clark County, Nevada, in the valley of Muddy River. The material has been known for some time as kaolin, and successful experiments for utilizing it as a porcelain clay have been made.

The United States Geological Sur-

vey reported that the quantity of crude magnesite sold during the calendar year, 1921, was 47,904 tons, valued at the mines at $510,177.

July 1. Ohio Sand & Gravel Producers Association withdraws from National Association.

Government road appropriation of $65,000,000.

August

Contracts awarded in the 27 eastern states during August amounted to $332,007,000, according to reports of the F. W. Dodge Company. This figure was 46 per cent over that of August, 1921, and only 8 per cent under that of July, 1922. The August figures brought the total for the year to date up to $2,362,872,000, which was not only the largest figure for the first eight months of any year, but was greater by $7,000,000 than the total for the entire year of 1921. Comparing the first eight months of 1922 with the first eight months of 1921, showed 1922 to be 58 per cent ahead. Contemplated new work reported during the month amounted to $371,249,000.

The southern states showed greater activity in road building and street paving work than at any time in its history. Contracts reported during the four months ending with July, aggregated in value about $40,000,000. Every state in the south showed tremendous progress, especially in road development.

Indiana crushed stone plants enjoyed great prosperity up to this point in the year. They had been running on 100 per cent time, had not been particularly affected by the car shortage and had ahead of them a vast amount of stone road construction requiring their products. Plants throughout the state reported a larger tonnage for August than for any other month in the year. The demand for crushed limestone as a fertilizer also contributed to the success of the season. Many quarries did a fine business in "chip" stone, which is very popular in places where the county or township has no road machinery. This stone is spread over the surface, raked smooth and rolled, and soon packs into an ideal roadway. It is also used considerably as a surfacing material into which bitumen is forced.

The railroad strike materially affected the sand and gravel business in Texas. The season in this section was very good up to the time car troubles began. Many large contracts for building projects remained without sand and gravel. The $6,500,000 worth of building projects in Dallas County alone were practically halted, and the activities of sand and gravel producers were considerably curtailed.

Railroad difficulties also gave a difficult aspect to the business of producing aggregates for use through Kentucky. Building operations in Louisville had been going on in boom style, however, and this furnished the local producers with some business. Building operations in Louisville had been going on through the summer season at a rate of $1,000,000 a month, and the indications at the beginning of August were that this month would pile up a million too. Throughout the state there were markets for all the aggregate that could be produced. The only trouble was cars.

Aug. 21. New Association of Illinois Sand & Gravel Producers formed.

Aug. 23. Wabash Valley District of Indiana Sand & Gravel Producers Association meets at Terre Haute.

Aug. 24. South Dakota signs contract with J. C. Buckbee for erection of new state-owned cement plant.

September

On September 20th and 21st, the members of the National Lime Association, held a special convention at the Hotel Sherman, Chicago, to discuss ways and means of giving additional force to progressive movements now going on within the Association. The chief concern of the gathering was to increase the demand for lime in construction and agricultural lines. For a number of years the use of lime in the chemical industry has been advancing much more steadily than it has in construction and agriculture, and it is desired to bring these departments up to the level of the chemical industry. The meeting voted a considerable enlarged budget for education and research and for promotional purposes. One important item of business at this meeting was the organization of the national association along territorial lines. The apportionment of all the states of the Union into three divisions, each in charge of a district manager, was approved, the district manager to have direct charge of development work in his town territory under

the supervision of the general manager of the Association who will be in charge of all association work. Under the direction of the general manager will also be a large technical staff devoted to construction, chemical and agricultural research.

On September first, Service Order No. 24 and Service Order No. 25 of the Interstate Commerce Commission, establishing priorities, became effective.

Declaring that Service Order No. 25, issued September 19th and made effective September 21st, by the Interstate Commerce Commission, although it superseded and modified Service Order No. 23, did not afford the relief sought, representatives of the National Association of Sand and Gravel Producers appeared before the Interstate Commerce Commission, Thursday, September 21st, asking for a further modification of priority orders that would give the sand and gravel industries sufficient open top cars to fill orders on hand and to meet the demand for their products. No action was taken during the month of September by the Commission as a result of the advancement of the producers' arguments before them.

The July record of the Lehigh Valley Cement district of Pennsylvania of having practically every mill in operation on a capacity basis and this undoubtedly for the first time in several years, would likely have been duplicated in August and September and later months of the year, but for the all-important consideration of fuel. Depleted coal supply and not very encouraging prospects for immediate replenishing of stocks, marred the situation, with the result that curtailment was necessary at a number of the mills. Aside from the coal situation, conditions and prospects in the cement industry were as bright as they had been for some time past. The demand was maintained at a high point, giving every indication that 1922 would be a banner year for the mills.

The report of the United States Bureau of Mines on the sale of permissible explosives in 1920 was given out this month and showed an aggregate purchase of 41,133,851 pounds. Except for the time when abnormal war-time conditions prevailed, more permissibles were sold in 1921 than in any other year. They are fast replacing other high explosives and blasting powder in coal mining operations and are being used more in quarries.

Business held brisk in the sand, gravel and crushed stone markets of New York and vicinity. Price quotations were strong with an inclination to tend upward in a number of instances. The coal situation was uppermost in mind and the effect of the railroad strike was more imaginary than real. Sand and gravel production kept up well and quite in accord with current demands. The quarries in northern New York, New Jersey and Pennsylvania showed no fear of any lack of coal and, when possible, run on a basis to allow for reasonable reserves during the winter season.

Gravel dealers in Texas were extremely hard hit during September by the lack of cars for loading sand and gravel, this shortage resulting directly from the priority order of the Interstate Commerce Commission which directed that coal cars be returned to the mines and loaded with nothing but fuel, until the existing coal shortage had been met. The coal shortage caused a shutdown in many of the pits, while others operated at about one-tenth normal capacity. Many large gravel companies with orders mounting into millions of dollars were unable to move material on account of inability to get cars.

The scarcity of open top cars was reported from many sections of Indiana and the famine worked considerable hardship on the many road improvement projects unfinished at that time. Several projects were held up on account of inability to get crushed stone from the quarries because of lack of cars.

While building operations in Louisville showed some signs of slowing down in September, the nine months of 1922 as a whole, will practically double the year before. This building boom, together with the program of street and alley construction, furnished a good run of local business for aggregate producers. The main trouble in the latter part of the summer was that of transportation. Local transactions were not hit so hard but where the material had to be sent by railroads the work was

slowed up and producers' schedules entirely deranged.

Operating regulations to govern the methods of mining oil shale, phosphate, sodium and potash on leased public lands of the United States, were issued in September by the Bureau of Mines, which is entrusted with the supervision of such operations. Copies of pamphlets containing all the operating regulations were published and may be obtained by addressing the Bureau of Mines, Washington, D. C.

September activities in Memphis and vicinity on sand, gravel, etc., were very good. The weather was favorable and the demand was persistent right along. Some trouble in getting cars was reported by operators, as many of the gravel and sand pits are located on branch lines and in competition with the harvest crop movement they have had to bide their time. Memphis, of course, is well situated for water transportation, some of the companies operating in that city having their own boats on the Mississippi.

Accidents at slate quarries in the United States during 1921 resulted in the death of 4 of the employees and the injury of 385, according to the Federal Bureau of Mines. Accident rates were 1.41 killed and 135.33 injured per 1,000 men employed 300 days, as compared with 1.49 killed and 108.20 injured last year.

Sept. 1. 90% loading approved by Trunk Line Association.
Service Order No. 24 effective.

Sept. 20. Special Convention National Lime Association at Chicago.
Service Order No. 25, superseding Order No. 23, effective.

Sept. 21. Special Lime Convention.
National Association of Sand and Gravel Producers asked for a further modification of the priority orders established in Service Order No. 25.

October.

In October was issued a set of figures that speak well for the general prosperity of the country and for the healthy condition in the pit and quarry industries. Sales of long term municipal bonds during September, totaled $94,590,507 against $66,360,551 for August, 1922, and $88,656,257 for September, 1921. This represents the highest total value for the month of September realized in any similar period during the past 30 years. The total for nine months, $905,770,787, was the highest for that period since 1892. Short term securities totaled $47,831,000. Records show that the number of municipalities issuing permanent bonds during September, 1922, and the number of separate issues, were 442 and 615 respectively as against 377 and 478 for September, 1921.

In view of the great and increasing importance of fluospar in the stone and ceramic industries, the Bureau of Mines decided to undertake an investigation of all phases of the fluospar industry in the United States. Examination was made of the principal deposits in the eastern and western states, this followed by an intensive study of the producing mines in Illinois and Kentucky. A report of all phases of the fluospar industry is in preparation.

Purdue University of Lafayette, Indiana, in cooperation with the United States Bureau of Public Roads, undertook a series of studies to determine the effect of various kinds of tires and various loads on concrete roads. It was the intention of the investigators to determine what kind of concrete would resist the destructive action of motor trucks, as well as to determine what kind of tires would add most to the life of a concrete road.

A decision was made to hold the annual Convention of the National Crushed Stone Association at Chicago, January 15, 16 and 17.

An optimistic tone prevailed in the sand, gravel and crushed stone markets of New York and vicinity, and producers maintained fair activity under favorable weather conditions. Prices showed no tendency to follow the normal downward seasonal trend of sales. Stone and gravel operators made the most of the seasonable weather to stock up for the winter months.

The Pennsylvania State Industrial Board handed down an important ruling holding that a minor between 16 and 18 years of age may serve as an apprentice at stone cutting, but not at a stone quarry. A general investigation of apprentices in the industries was ordered.

There was a noticeable scarcity of railroad cars for sand and gravel transportation in Pennsylvania during October, resulting in the accumulation

of stocks in a large number of plants.

Mr. T. R. Barrows was appointed Executive Secretary to the National Sand and Gravel Association to succeed Mr. E. Guy Sutton.

Experiments conducted in California, demonstrated that the mixing of cement with certain types of soil to alter the soil and make it more suitable for road surfacing and subgrading, is entirely feasible and does away with the usual shrinkage cracks, particularly characteristic of adobe soils.

Eastern cement manufacturers had considerable difficulty making cement shipments by reason of the fact that railroad companies would not accept shipments of empty bags from dealers to the mills.

The advance of the fall season did not show any marked change in the activities of sand and gravel producers around Pittsburgh. Banner weeks in sand output have recorded towboats ranging as high as 15,000 tons of material handled in a seven day period. Prices maintained substantially the levels that had prevailed for some time.

Dr. Oliver Bowles, mineral technologist of the Bureau of Mines, completed his investigations on slate, the study involving visits to practically all working quarries and finishing plants in the country. The purpose was to promote efficiency and waste elimination in the industry and to find uses for unavoidable waste. A direct result of this interest in the development of slate was the establishment of the National Slate Association. Several short reports were issued and a final bulletin was submitted for publication.

It was announced that the American Road Builders Association would conduct the 13th American Good Roads Congress and the 14th National Good Roads Show in Chicago, January 15 to 19, 1923. For the second time the National Crushed Stone Association was to hold its annual convention during that same week.

It was announced that $10,000,000 are paid out annually to producers of gravel, stone and sand for the construction of buildings in Los Angeles county.

Oct. 9-14—American Mining Congress—Annual Convention—at Cleveland.

November.

During November was issued a very interesting paper by Oliver Bowles, Mineral Technologist, U. S. Bureau of Mines, on "Stripping Problems in Limestone Quarries of Shenandoah Valley."

On November 15th at Chicago representative sand and gravel producers of the United States, members of the National Association of Sand & Gravel Producers, adopted a new constitution which changed the name to the National Sand & Gravel Association. The high lights of the new document, points in which it differs from the old constitution, are those concerned with the methods of individual and district representation, the payment of dues and the organization of the administrative machinery of the association. A few days after the meeting members of the association throughout the country voted by mail on the question of a convention site, and decided upon Washington.

The state of Texas, although operating under the disadvantage of a scarcity of railroad cars, enjoyed a good business during November, as a result of the very fine weather that prevailed. There was little or no decline in building, and road construction and street paving works went ahead with redoubled activity.

Cement mills of the Lehigh Valley section of Pennsylvania maintained operations at a maximum point. The companies during this time were devoting all their attention to piling up a sufficient reserve of finished stock to permit them to shut down the mills because of the absolute necessity for repairs.

Louisville reported a good season chiefly as a result of the building boom throughout the year.

Good activity prevailed in the sand and gravel markets of Pittsburgh, Pa., and in addition there was plenty of dredging work going the rounds to enhance the operations of a number of prominent sand digging companies. The clear open weather helped the situation and there was no thought of anything more than seasonal curtailment.

Nov. 15—Constitutional Convention of National Sand and Gravel Producers at Chicago. New constitution adopted.

December

Hundreds of pit and quarry operators replied to a form letter from PIT and QUARRY asking for an expression of opinion on the advisability of conducting operations in three shifts through the whole 24 hours. Few whole-hearted supporters of the plan were found, although some producers said that their experiences along these lines were very satisfactory.

In December came assurance that the Annual Convention of the National Crushed Stone Association at Chicago, January 15-17, would be a record-breaker. A full program was given out.

The National Sand & Gravel Association announced that addresses on every phase of the sand, gravel and stone industry would be delivered by men of national prominence at the Association's convention in Washington, January 24, 25 and 26. At this time a good attendance was assured.

On Thursday, December 21st, members of the Wisconsin Mineral Aggregate Association held their regular annual meeting at the Hotel Pfister, Milwaukee. Many matters of interest to producers were thoroughly discussed. After the business sessions, the members met at dinner, where they were addressed by well-known speakers.

At Kansas City on December 14 and 15 the Missouri Valley Association of Sand & Gravel Producers held their annual meeting. Harry E. Moore of the Missouri River Sand & Gravel Company, Booneville, Mo., was elected president for the new year, succeeding J. M. Chandler of the Price Sand Company, Tulsa, Okla.

It was announced that the National Slate Association would hold meetings at the Commodore Hotel, New York City, on January 22 and 23.

The situation in the sand, gravel and crushed stone markets at New York and vicinity was very encouraging for this season of the year. The activity in the general building supply business in this section was reflected in the calls for sand, gravel and affiliated material for construction service. Supply dealers continued to stock up in these lines with surprising regularity. Labor conditions in this section were not of the best.

The revocation of priority ordinance which gave preferential car service to the transportation of coal became effective at midnight of December 11. The removal of these orders was a distinct victory for the National Sand & Gravel Association, who had strenuously opposed their adoption.

Operations in the sand and gravel industry in the Pittsburgh, Pa., district continued at a good point, and sizeable cargoes reached the local port from the river points for immediate distribution.

"Failure of Center Shots in Blasting" was explained in detail in Serial 2384 of the Bureau of Mines, Washington, D. C. Copies may be obtained by ordering from the Bureau under that serial number. Bureau of Mines Serial 2405, also a new publication, gives the regulations for electric shot firing.

Dec. 14—Annual meeting of Missouri Valley Association of Sand and Gravel Producers at Kansas City.

Dec. 21—Annual meeting of Wisconsin Mineral Aggregate Association at Hotel Pfister, Milwaukee.

Directory of Associations

National Agricultural Limestone Association.—Pres., Edgar M. Lamkin, Kelley Island Transport Co., Cleveland, Ohio; V. Pres., R. J. Fuller, Columbia Products Co., Cleveland, Ohio; Treas., W. H. Margraf, Marble Cliff Quarries Co., Columbus, Ohio; Sec., A. P. Sandles, 405 Hartman Bldg., Columbus, Ohio.

National Sand and Gravel Association.—Pres., Alex. W. Dann, Keystone Sand Supply Co., Pittsburgh, Pa.; V. Pres., E. G. Sutton, Danville, Ill.; Ex. Sec., T. R. Barrows, 903 Munsey Bldg., Washington, D. C.; Treas., John Prince, Stewart Sand Co., Kansas City, Mo.

National Crushed Stone Association.—Pres., F. W. Schmidt, Morris County Crushed Stone Co., Morristown, N. J.; 1st V. Pres., W. H. Hoagland, Marble Cliff Quarries Co., Columbus, Ohio; Sec., A. P. Sandles, 405 Hartman Bldg., Columbus, Ohio.

National Federation of Construction Industries.—Pres., Ernest T. Trigg, John Lucas Co., Inc., 322 Race St., Philadelphia, Pa.; Treas., A. M. Maddock, Thomas Maddock's Sons Co., Trenton, N. J.; Gen. Sec., W. S. Hays, Drexel Bldg., Philadelphia, Pa.

National Lime Association.—Pres., Chas. Warner, Chas. Warner Co., Wilmington, Del.; Sec., W. R. Phillips, 918 G Street, Washington, D. C.

National Slag Association.—Pres., L. A. Beeghly, Standard Slag Co., Youngstown, Ohio: V. Pres., C. E. Ireland, Birmingham Slag Co., Birmingham, Ala.; Sec.-Treas., H. J. Love, 933 Leader-News Bldg., Cleveland, Ohio.

National Slate Association—Pres., W. H. Keenan, Keenan Structural Slate Co., Bangor, Pa.: Sec., W. S. Hays, 757 Drexel Bldg., Philadelphia, Pa.

American Road Builders' Association.—Sec., E. L. Powers, 11 Waverly Place, New York, N Y.

American Sand Association (Moulding Sand).—Pres. Theo. B. Ely, Venango Sand Co., Franklin, Pa.; 1st V. Pres., W. H. Smith, Superior Sand Co., Cleveland, Ohio; 2nd V. Pres., E. E. Klooz, Portage Silica Co., Youngstown, Ohio; Sec.-Treas., Hubert B. Fuller, 826 Guardian Bldg., Cleveland, Ohio.

Eastern Stone Association.—Pres., John Rice, General Crushed Stone Co., Easton, Pa.; V. Pres., J. D. Budding, J. C. Budding Co., Lancaster, Pa.; Sec.-Treas., H. B. Allen, General Crushed Stone Co., 417 North American Bldg., Philadelphia, Pa.

Great Lakes Sand & Gravel Producers' Association.—Pres., John M. Cameron, Detroit, Michigan: V. Pres., Fred W. Ohelmacher, Sandusky, Ohio; Sec.-Treas., Joseph T. Farrel, Sandusky, Ohio.

Gypsum Industries.—Pres., Ray C. Haynes, St. Louis, Mo.; V. Pres., James Leenhouts, Grand Rapids, Mich.; Sec., H. H. McDonald, 111 West Washington St., Chicago, Ill.; Chief Engineer, Virgil G. Marani, Agricultural Adviser, Wm. Crocker.

Missouri Valley Association of Sand & Gravel Producers.—Pres., Harry E. Moore, Missouri River Sand & Gravel Co., Booneville, Mo.; Treas., W. E. Rogers, Sand Springs, Okla.; Sec., W. Johnson, Minor Bldg., Kansas City, Mo.

Ohio Valley Sand & Gravel Association.—Pres., W. H. Merrill, West Virginia Sand & Gravel Co., Charleston, W. Va.; V. Pres., W. C. Tisher, The River Sand Co., Steubenville, Ohio; Sec., A. P. Turley, Ohio River Gravel Co., Parkersburg, W. Va.; Asst. Sec., Wm. E. Shivers, New Martinsville Sand Co., New Martinsville, W. Va.; Traffic Counsellor, Chas. Donley, Century Bldg., Pittsburgh, Pa.

Portland Cement Association.—Pres., F. W. Kelley, Helderberg Cement Co., Albany, N. Y.; Gen. Mgr. & Sec., Wm. Kinney, 111 W. Washington St., Chicago, Ill.

Talc & Soapstone Producers Association.—Pres., Freeland Jewett, The Eastern Talc Co., International Trust Co. Bldg., Boston, Mass.; Sec., R. B. Ladoo, 1448 Girard St., N. W., Washington, D. C.

Tri-State Road Material Association.—Pres., Ashleigh Harleston, Harleston

Gravel Co., Greenwood, Miss.; V. Pres., W. L. Smith, Memphis Stone & Gravel Co., Memphis, Tenn.; V. Pres., C. H. Miller, Allen Gravel Co., Memphis, Tenn.; V. Pres., W. H. Rucker, Newhope Gravel Co., Columbus, Miss.; Sec.-Treas., Geo. W. Fooshe, Camden Road Material Co., Memphis,

United States Potash Producers Association.—Pres., W. E. Richardson, Hord Potash Co., Central City, Nebr.; V. Pres. & Treas., Arthur C. Harragin, American Trona Corp., New York, N. Y.; Ex. Sec., Frederick W. Brown, 800 Southern Bldg., Washington, D. C.

California Rock, Sand & Gravel Producers Association.—Pres., Anson S. Blake, Blake Bros. Co., San Francisco, Calif.; Sec.-Treas., Clarence F. Pratt, Pratt Bldg. Material Co., Hearst Bldg., San Francisco, Calif.

Illinois Sand & Gravel Association.—Pres., H. H. Halliday, H. H. Halliday Sand Co., Cairo, Ill.; V. Pres., O. J. Ellingen, H. D. Conkey Co., Mendota, Ill.; Sec.-Treas., T. E. McGrath, McGrath Sand & Gravel Co., Lincoln, Ill.; Executive Committee, H. E. Neal, Neal Gravel Co., Mattoon, Ill., and Beder Wood, Beder Wood & Sons, Moline, Ill.

Indiana Crushed Stone Association.—Pres., C. E. Greely, Greely Stone Co., St. Paul, Ind.; V. Pres., Bernard L. McNulty, Lehigh Lime Co., Chicago, Ill.; Treas., V. G. Pogue, Spencer Stone Co,, Indianapolis, Ind.; Sec. F. W. Connell, 802 Hume-Mansur Bldg., Indianapolis, Ind.

Indiana Limestone Quarrymens' Association.—Pres., T. J. Vernia, Indiana Quarries Co., Chicago, Ill.; V. Pres., S. C. Freese, National Stone Co., Bloomington, Ind.: Treas., R. M. Richter, Furst-Kerber Cut Stone Co., Bedford, Ind.; Act. Secy., Edgar Lunn, Bedford, Ind.; Service Engineer, H. S. Brightly, Bedford, Ind.

Indiana Sand & Gravel Producers Association.—Pres. J. A. Shearer, Indianapolis; V. Pres., L. R. Witte, Terre Haute; Ex. Sec. and Engineer, R. C. Yeomans 603 Occidental Bldg., Indianapolis, Ind.

Iowa Sand & Gravel Producers Association.—Pres., R. C. Fletcher, Flint Crushed Gravel Co., 907 Bankers Trust Bldg., Des Moines, Iowa: V. Pres., Geo. H. Boynton, Northern Gravel Co., Muscatine, Iowa; Sec., Willard H. Graham, 7 Commercial Securities Bldg., Des Moines, Iowa.

Kentucky Crushed Stone Association.—Pres., W. J. Sparks, W. J. Sparks Co., Mt. Vernon, Ky.; V. Pres., F. W. Katterjohn, F. W. Katterjohn Construction Co., Paducah, Ky.; Sec.-Treas., R. B. Tyler, R. B. Tyler Stone Co., 114 S. 4th St., Louisville, Ky.

Michigan Sand & Gravel Producers Association.—Pres., Lees E. Denton, Federal Sand & Gravel Co. Saginaw, Mich.; V. Pres., W. F. Fisher, Tecumseh Gravel Co., Tecumseh, Mich.; Sec.-Treas., Paul D. Hoel, care of Greenville Gravel Co., Kalamazoo, Mich.; Ex. Sec., G. J. Bolander, 509-510 Press Bldg., Kalamazoo, Mich.

Nebraska Mineral Aggregate Association.—Pres., L. C. Curtis, Lyman-Richey Sand Co., Omaha Nebr.; V. Pres., F. Cone, Consumers Sand Co., Valley, Nebr.; Sec., C. E. Walsh, attorney, 317 McLague Bldg., Omaha, Nebr.; Treas., Thomas Sullivan, National Stone Co., Omaha, Nebr.

Ohio Macadam Association.—Pres., E. E. Evans, Toledo Ohio; 1st V. Pres., G. H. Faist, Toledo, Ohio; 2nd V. Pres., B. T. Van Camp, Cincinnati, Ohio; Treas., W. H. Hoagland, Columbus Ohio; Sec., A. P. Sandles 405 Hartman Bldg., Columbus, Ohio; Asst., Claude Clark, Columbus, Ohio.

Ohio Sand & Gravel Producers Association.—Pres., Fred E. Hall, T. J. Hall & Co., 450 E. Pearl St., Cincinnati, Ohio; V. Pres. E. A. Evans, Zanesville Washed Gravel Co., Zanesville, Ohio; Sec.-Treas., F. C. Fuller, Portsmouth Sand & Gravel Co., Portsmouth, Ohio; Ex. Sec., Guy C. Baker, Greenville Gravel Co., Greenville, Ohio.

Pennsylvania Sand & Gravel Producers Association.—Pres., Jos. R. McGaw, Ohio River Sand Co., Pittsburgh, Pa.; V. P., A. W. Dann, Keystone Sand and Supply Co., 1101 Diamond Bank Bldg., Pittsburgh, Pa.; S. & T., Harry Davison, J. K. Davison & Bro., Inc., Pittsburgh, Pa.; Ex. Sec., C. C. Whiteside, Rock Point Sand Co., Wabash Bldg., Pittsburgh, Pa.

Wisconsin Mineral Aggregate Association.—Pres., J. K. Jensen, Janesville Sand & Gravel Co., Janesville, Wis.; V. Pres., John D. Ohrt, Davis Brothers Stone Co., Lannon, Wis.; Sec.-Treas., I. M. Clicquennoi, Wisconsin Sand & Gravel Co., Milwaukee, Wis.; Ex. Sec., N. K. Wilson, Railway Exchange Bldg., Milwaukee, Wis.

Injuries and Their Treatment

Hemorrhage.

Hemorrhage is loss of blood. It is caused usually by an injury or by a diseased condition of the blood vessels. The danger from hemorrhage depends upon the amount of blood lost and the rapidity with which it escapes. The loss of one-third of the blood in the body usually results fatally.

There are three kinds of hemorrhage, namely, arterial, capillary, and venous. Arterial hemorrhage is most dangerous and most difficult to control.

Hemorrhage may be controlled by pressure, position, heat or cold, torsion, or ligation or tying of the blood vessel.

The only methods which can usually be employed by the first-aid man are compression and position. Compression is more important and should be applied by the fingers, compresses, torniquets, or constricting bands, such as a handkerchief, belt strap, suspenders, etc.

In arterial hemorrhage the blood gushes forth in a bright-red stream. The pressure must be made between the wound and the heart. In capillary hemorrhage, the blood oozes away slowly and is bright red. The bleeding is easily controlled by applying a clean compress of gauze directly to the injury. In venous hemorrhage the blood is dark red or blue and discharges in a steady stream. The compression should be made on the side of the wound away from the heart. Usually the bleeding can be controlled by applying a large compress of sterile gauze over the bleeding place.

Elevation of the bleeding parts always aids in controlling the flow of the blood. As soon as the bleeding has been stopped by some one of the methods suggested the patient should be treated for shock.

Shock.

Shock is a sudden depression of the vital powers arising from an injury or a profound emotion acting on the nerve centers and inducing exhaustion. The symptoms are subnormal temperature; an irregular, weak, and rapid pulse; a cold, clammy, pale, and profusely perspiring skin; irregular breathing; the person affected usually remains conscious and will answer when spoken to but is stupid and indifferent and lies with partly closed lids. Always be sure that there is no concealed hemorrhage. The symptoms of concealed hemorrhage are practically the same as outlined above.

Lower the patient's head, wrap him in hot blankets, and surround him with such heat-giving objects as are available. Give an ordinary stimulant, as black coffee, to be sipped as hot as it can be borne; half-teaspoonful doses of aromatic spirits of ammonia may be given every 20 or 30 minutes. Small doses of whisky or brandy may be given, provided there is no hemorrhage. One or two teaspoonfuls every 15 or 20 minutes will help to tide the patient over until the doctor comes. Inhalation of exygen is often of much service; artificial respiration may be necessary in some cases. Hot applications over the heart and spine should be used if practicable. Always hurry up the doctor.

Contusions.

A contusion or bruise is an injury due to the application of blunt force, the skin above being unbroken. Blood collects in the tissue under the skin over the bruised area. In many deep contusions the skin is not damaged, but over bone the skin is apt to be injured. If a large blood vessel is ruptured, much blood gathers in the tissues under the skin and causes great swelling and discoloration.

The symptoms are Tenderness, swelling, and numbness, followed by aching pain. Discoloration usually occurs quickly, especially in surface contusions; it may not occur in deep ones.

Elevate the injured part and bandage it tightly to arrest the bleeding and control the swelling. Apply an icebag or towels wrung out of ice water. In the case of the aged or weak make hot applications instead of cold.

Wounds.

A wound is a break or a division of the tissues produced usually by a

sudden force. Wounds are divided into the following classes: Incised, made by some sharp cutting instrument; contused, caused by a blunt or flat or rough instrument; lacerated, caused by tearing or dragging forces, such as teeth and claws of animals or punctures made by a pointed instrument.

The symptons are: Pain, bleeding, and gaping or retracted edges.

First arrest the bleeding by some one of the methods described above, and put on a sterile dressing to protect the wound against bacteria or germs. If the wound is very severe, there is often shock, and that should be treated as described above. (See "Shock.")

Fractures.

A fracture is a break in a bone caused by direct or indirect violence. Fractures are the most important class of injuries with which we have to deal, not only because they render the victim a cripple for the time being, but because the further usefulness of the limb depends upon the recognition of the trouble and its proper immediate treatment. Frequently ignorance or carelessness in handling a fracture in the beginning renders the sufferer an invalid or cripple throughout his life.

From the standpoint of the first-aid man the following kinds of fracture only need be studied: Incomplete, complete, simple, and compound. In an incomplete fracture the bone is not entirely broken. It occurs most frequently in the young and is often spoken of as a green-stick fracture. In a complete fracture the bone is broken completely in two. In a simple fracture the broken bone does not protrude through the flesh; that is, the flesh around the fracture is not injured. In a compound fracture either one of the broken ends protrudes through the flesh or else the force that caused the fracture cuts or tears the flesh down to the bone. A compound fracture is nearly always accompanied by a loss of blood and a more or less severe shock.

The symptoms are: Pain, swelling, discoloration, abnormal motion, loss of power, and crepitus or grating of the bone ends together.

In examining the fracture, great gentleness in handling the part should be exercised. The limb should be handled as little as possible. If the nature of an injury is in doubt, it should be treated as a fracture until the doctor arrives. Never allow a person suffering from a broken limb to be moved until the part is properly supported by splints. To treat a fracture, draw the fractured limb into a natural position and fix it there by the application of splints.

Dislocations.

A dislocation is a complete separation or displacement of the surfaces of a joint, caused usually by direct violence, but may sometimes be produced by indirect violence or sudden muscular contraction. Dislocations are always painful, because they are accompanied by wrenching and tearing of the ligaments about the joint and are sometimes complicated by a rupture of the muscles and by injuries to surrounding vessels and nerves.

Dislocations are classed as simple, compound, and complicated. In a simple dislocation the articular ends are separated without injury to the surrounding tissues. In a compound dislocation the ligaments around the joint are torn. In a complicated dislocation the muscles, vessels, and nerves are injured.

The symptoms are: Pain, swelling, discoloration, rigidity; the natural position of the limb is changed; the length is altered.

Restore the bone to normal position and hold it in place. To properly reduce the dislocation, some surgical skill and knowledge of the anatomy of joints are required. First-aid men should never try to reduce any dislocations except of the jaw and fingers.

Sprains.

A sprain is a twisting or wrenching of a joint, producing a tearing of the ligaments and sometimes of the surrounding soft parts. It is followed by severe pain and marked swelling and discoloration. Sprains are important injuries and should be properly treated immediately, as sometimes permanent disability may follow failure to give them proper care. They are very often more serious than a fracture.

Let the injured person rest; elevate the injured part and fix it in place either with splints or by wrapping the joint tightly with a roller band-

age or with adhesive plaster. Give hot or cold applications by placing the injured part in hot or cold water or by the application of towels wrung out of ice water or hot water.

Strains.

A strain is the wrenching or tearing of a muscle or tendon and is usually caused by violent exertion or sudden unexpected movements. A strain generally occurs in the muscles or tendons of the arms or legs. The symptom is sudden, sharp, excruciating pain.

Let the injured person rest; bandage the injured part tightly or apply adhesive plaster. It is sometimes necessary to prevent movement or the part by splinting.

Treatment for Electric Shock.

The following directions for treatment of electric shock are taken from Miners' Circular 5 of the Bureau of Mines:

When a man has received an electric shock that leaves him senseless, two things should be done as soon as possible.

First, remove the victim from contact with the electric wire.

Second, revive him or "bring him to" by getting him to breathe.

While removing the victim from the electric circuit, be careful not to get a shock yourself. If there is a switch right at hand, cut off the current at once; but if there will be any delay in cutting off the current, remove the body from the circuit by means of a piece of dry wood, used either to roll or push the body aside or to lift from the body whatever is carrying current to it. Tools with dry wooden handles, such as picks or axes, may be safely used for this purpose.

The body of the victim can be safely grasped if your hands are protected by several thicknesses of dry cloth, or if you stand upon a piece of dry wood.

When you can do nothing else, you may be able to short-circuit the line with which the victim is in contact, and thus blow the circuit breaker or fuses which protect that part of the electric system.

A short circuit may be made by placing an auger or drill or a piece of pipe so that it will connect the two sides of the electric circuit. For example, in case the victim is in contact with a trolley wire, the auger, drill, or pipe should be thrown across the trolley wire and track rail, so as to be in contact with both. In doing this, be sure that the auger, drill, or pipe leaves your hand before it touches the current-carrying part of the circuit, as otherwise you will get a shock yourself.

Artificial Respiration.

When the victim has been removed from contact with the current, artificial respiration should be begun at once. There are several ways of performing artificial respiration. Those most commonly used are the Schaefer method and the Silvester method, each of which is advocated by physicians who have had experience in mine-rescue work.

The Schaefer method is favored by a commission representing the American Medical Association, the National Electric Light Association, and the American Institute of Electrical Engineers for use in reviving persons overcome by electric shock, and the method will be generally practiced by the Bureau of Mines in its mine-rescue work until some better method has been devised. Both the Schaefer and the Silvester methods are described below:

Schaefer method. Rapidly feel with the finger in the victim's mouth and throat and remove any foreign body (tobacco, false teeth, etc.); then begin giving artificial respiration at once. Proceed as follows

Lay the subject on his belly, with arms extended as straight forward as possible, and with face to one side, so that the nose and mouth are free for breathing. Draw forward the subject's tongue.

Kneel, straddling the subject's thighs and facing his head; rest the palms of your hands on the loins (on the muscles of the small of the back), with thumbs nearly touching each other, and with fingers spread over the lowest ribs.

With arms held straight, swing forward slowly so that the weight of your body is gradually brought to bear upon the subject. This operation, which should take from two to three seconds, **must not be violent**—internal organs may be injured. The lower

part of the chest and also the abdomen are thus compressed, and air is forced out of the lungs.

Now immediately swing backward so as to remove the pressure, but leave your hands in place, thus returning to the original position. Through their elasticity, the chest walls spring out and the lungs are thus supplied with fresh air.

After two seconds swing forward again. Thus repeat deliberately twelve to fifteen times a minute the double movement of compression and release—a complete respiration in four or five seconds. If a watch or clock is not visible, follow the natural rate of your own deep breathing—swinging forward with each expiration and backward with each inspiration.

Silvester method. Turn the patient on his back, loosen the clothing from around his neck, chest, and abdomen, and place a small log, a rolled-up coat, or something of similar size and shape under his shoulders in such a way as to throw his head back and his chest up.

Then draw out the victim's tongue by grapsing it with a piece of dry cloth. This act clears the windpipe, and unless it is done, the victim can not be made to breathe. If the rescuer is alone, he will have to keep the tongue drawn forward by tying it with a handkerchief or a bandage passed over the tongue and under the jaw. The tongue must be held in this position while artificial respiration is being given.

Kneel behind the head of the victim, grasp his forearms just below the elbows and draw them slowly backward until they are extended as far as possible over his head and hold them there for about one second.

Then slowly push the elbows forward and downward. Next press the elbows firmly against the chest and hold them there for about one second so as to drive out the air from the lungs.

Do not perform these movements hurriedly; pumping the arms up and down is a waste of time. To complete one series of movements should take about four seconds. A very good way to time yourself is to count, very slowly, "one, two, three, four," while making the movements. Count "one" as the victim's arms are being extended, count "two" while they are held above his head, count "three" while his arms are being returned to his side, and count "four" while exerting pressure on his chest.

Usually a victim of electric shock can be made to breathe within one hour, but artificial respiration should be continued, without interruption, at least two hours, even though the patient does not show any signs of life.

If other persons are at hand, have them assist by relieving you at short intervals, and have them keep the victim warm by covering him with coats or anything suitable that may be had. After the victim begins to breathe the assistants should rub his limbs briskly and toward the heart, keeping their hands under the covering while doing so. This will help to restore the circulation of the blood, which has been for a time suspended.

Do not give any liquids by mouth until the subject is fully conscious.

Treatment of Burns and Scalds.

While arrangements are being made for removing the injured man to his home or to a hospital, treat any injuries that he has received. Treat electric burns exactly as ordinary burns. Before the arrival of a doctor it is proper to cover the burnt place with several thicknesses of picric-acid gauze. This gauze is now being used in nearly all mines and hospital emergency rooms.

In case no picric-acid gauze is at hand the burns may be covered with clean gauze, preferably taken from sterile packages, and covered with vaseline, carbolized vaseline, olive oil, or balsam oil. Carron oil, which is a mixture of linseed oil and limewater, has been used as a dressing for burns, but its use is not recommended.

Cover these dressings with plenty of cotton and protect this in turn from the outside air with oiled paper or anything that will keep out the air while the victim is being taken home or to a hospital.

Bandage all dressings lightly so as to cause as little pressure as possible upon the injuries.

Electrical Shot Firing Regulations

The Bureau of Mines recommends that wherever it is feasible to adopt electrical shot-firing for either mining or quarry work, this should be done as a safety measure. Electrical shot-firing when properly carried out, eliminates some of the inherent dangers of fuse and squib firing.

Several States have already, by regulation or enactment, covered the question of electrical shot firing.

California has the following rules covering electric shot firing, issued by the Industrial Accident Commission, effective Jan. 1 1919:

Rule 629 (d). When electricity is used to fire shots, it shall not be permitted for any person knowingly to enter the vicinity of the place where such shots have been fired, until the cable from the source of electrical energy to the blasted holes shall have been disconnected and short circuited. It shall be the duty of the boss or shot firer to see that all such cables are disconnected immediately after such firing, and to examine or direct such examination of such place where shots have been fired before any men are permitted to work therein. Men must wait at least five (5) minutes before returning to the point of blasting.

(e). It shall be the duty of the boss or shot firer to see that special precautions are taken against the shot firing cables or wires coming into contact with the lighting, power or other circuits, or with any metal pipe lines. All portable devices for generating or supplying electricity for shot firing shall be in charge of a boss or shot firer. No person other than a boss or shot firer shall connect the firing machine or battery to the shot firing leads, and such connection shall not be made until all other steps preparatory to the firing of a shot shall have been completed, and the men removed to a safe distance. Batteries used for shot firing shall be provided with a suitable case in which all contacts shall be made or broken, except that the binding posts for making connections to the firing leads may be outside.

(f). Electricity from light or power circuits shall not be used for firing shots, except where the electrical connections to such light or power circuits are made within an inclosed switch box, which shall be kept securely locked and shall be accessible only to the authorized boss or shot firer.

The Department of Labor, State of New York Industrial Commission, has issued the following rules relating to shot firing in quarries, effective July 1, 1918:

Rule 1106 (n). Firing shall be done by safety fuse or approved battery or from an electric current of not over two hundred and fifty (250) volts, provided a suitable switch is used, as hereinafter described. Other methods of firing may be permitted upon application and approval by the Industrial Commission.

(o). When firing by electricity from power or lighting wires in any quarry, a proper switch shall be furnished with lever down when "off." The switch shall be fixed in a locked box to which no person shall have access except the blaster. The lead wires shall be furnished with plugs and shall not be connected with the switch till ready to fire. After blasting, the switch lever shall be pulled out, the wires disconnected, and the box locked before any person shall be allowed to return, and shall remain so locked until again ready to blast.

(p). All power lines and electric light wires shall be disconnected at a point outside the blasting switch before explosives are taken in and loading of holes is proceeded with. No current by grounding of power or lighting wires or bonded rails shall be allowed beyond blasting switch after explosives are taken in preparatory to blasting, and under no circumstances shall grounded current be used for exploding blasts.

(q). The blaster shall cause a sufficient warning to be sounded and shall be responsible that all persons retreat to safe shelter before he sets off blast, and shall also see that none return until he reports it safe for them. He shall report to the quarry foreman and furnish names of all persons refusing to obey his caution. Suitable and convenient shelters shall be provided.

(r). When a blaster fires a round of holes, he shall count the number of shots exploding, except in case of instantaneous blasting by electricity. If there are any misfires, he shall report the same to the gang boss or foreman. The blaster shall not leave until he has placed a wooden plug painted red, or other proper danger signal, in the mouth of the missed hole. If a missed hole has not been fired at the end of a shift, that fact, together with the position of the hole, shall be reported by the quarry foreman or shift boss to the quarry foreman or shift boss in charge of the next relay of quarrymen, before work is commenced by them.

(t). All wires in broken ore or rock shall be carefully traced and search made for unexploded cartridges.

(v). Blasters, when testing circuit through charged holes, shall use sufficient leading wires to be at a safe distance and shall use only approved types of galvanometers. No tests of circuits in charged holes shall be made until men are removed to safe distance.

New York Industrial Code Bulletin No. 25 (effective May 1, 1922), gives the follwing rules governinng electric shot firings in tunnels:

Rule 1357 (f). Detonators shall be inserted in the explosives only as required for each round of blasting. Detonators shall not be inserted in the explosives without first making a hole in the cartridge with a sharpened stick. No holes shall be loaded except those to be fired at the next round of blasting. All explosives remaining after loading a round must be removed from the heading before any wires are connected.

All lights used when loading shall be an enclosed type. If electric flash lamps are used, they shall be so constructed that it will not be possible to obtain a difference of potential between any two points on the outside of the lamp casing.

(k). When a blaster fires a round of holes he shall count the number of shots exploding, except in cases of instantaneous blasting by electricity. If there are any misfires, he shall remain until such misfires have been exploded or holes made safe.

(Note: Misfires should not be approached even for the purpose of inspection until three hours have elapsed if fuse is used, or ten minutes have elapsed if electric blasting caps have been used, lest the trouble be a hang-fire and not a misfire.

(n). Firing shall be done by safety fuse or approved battery or from an electric current of not over 250 volts, provided a suitable switch is used, as hereinafter described. Other methods of firing may be permitted upon application to and approval by the Industrial Commissioner.

(o). When firing by electricity from power or lighting wires in any tunnel, a proper switch shall be furnished with lever down when "off." The switch shall be fixed in a locked box, to which no person shall have access except the blaster. There shall be provided flexible leads or connecting wires not less than 5 feet in length with one end attached to the incoming lines and the other end provided with plugs that can be connected to the switch on the inside shot-firing circuit when firing and that shall at all other times be connected to an effective ground. After blasting, the switch lever shall be pulled out, the wires disconnected and the box locked before any person shall be allowed to return, and shall remain so locked until again ready to blast, and blasting wires must be laid on the opposite side of the tunnel from the lighting and power wires.

(p). All power lines and electric light wires shall be disconnected at a point outside the blasting switch before loading of holes is proceeded with. No current by grounding of power or bonded rails shall be allowed beyond blasting switch after explosives are taken in preparatory to blasting, and under no circumstances shall grounded current be used for exploding blasts.

(t). All wires in broken rock shall be carefully traced and search made for unexploded cartridges.

(v). Blasters, when testing circuit through charged holes, shall use only sufficient leading wires to be at a safe distance and shall use only approved types of galvanometers. No tests of circuits in charged holes shall be made until men are removed to safe distance.

Arizona.

Mining Code, Revised Statutes, 1913. Sec. 4071 (e). Before firing charges, warning must be given in every direction from which access may be had to the place where blasting is going on, and misfire holes shall be reported to the mine foreman, or the shift boss, in charge of the locality of such holes. If the shots are fired by electricity, the place must be carefully examined before men are permitted to work therein. The miner in charge shall further instruct those employed in clearing away the loose rock, to report to him immediately the finding of any wires in or under the loose rock, and in the event of such being discovered, he shall at once order the work to cease until the wires have been carefully traced to their terminals in order to determine whether a misfire has occurred.

Utah.

General Safety Orders, Covering Underground Metal Mining Operations, issued by the Industrial Commission of Utah, effective August 15, 1919. Sec. 22 (d). When electricity is used to fire shots, it shall not be permitted for any person knowingly to enter the vicinity of the place where such shots have been fired, until the cable from the source of electrical energy to the face of the blast shall have been disconnected. It shall be the duty of the boss or shot firer to see that all such cables are disconnected immediately after such firing and to examine or direct the examination of such place where shots have been fired before any men are permitted to work therein.

(e). It shall be the duty of the boss or shot firer to see that special precautions are taken against the shot-firing cables or wires coming into contact with the lighting, power, or other circuits, or with any metal pipe lines. All portable devices for generating or supplying electricity for shot firing shall, when in the mine, be in charge of a boss or shot firer. No person other than a boss or shot firer shall connect the firing machine or battery to the shot-firing leads, and such connection shall not be made until all other steps preparatory to the firing of a shot shall have been completed, and the men removed to a safe distance.

If the firing unit is of the battery type, the battery shall be enclosed in an efficiently locked casing designed only for shot firing service. Combination units designed for both blasting and illumination will not be approved.

The outer casing must be mechanically strong and cover the battery terminals in such a way that there is no possibility of completing a circuit except by plugging into an approved receptacle.

The receptacle and plug must be so designed that contact to both battery terminals is made simultaneously and that immediately after the shot, the plug shall be projected free from its receptacle.

If the unit is of the magneto type, the magneto casing must be mechanically strong and must have an efficient lock or other adequate means of preventing the operation of the magneto except through the use of an approved device.

The design of magnetos for shot firing service shall be such as to prevent the passage of current to the external circuit until the maximum voltage of the magneto has been developed.

(f). Electricity from light or power circuits shall not be used for firing shots in a mine, except where the electrical connections to such light or power circuits are made within an inclosed switch box, which shall be kept securely locked and shall be accessible only to the authorized boss or shot firer. The shooting wires must be protected from lightning by a removable lightning arrester of 6 feet, which shall be kept open whenever holes are being loaded or connections being made with the wires.

American Table of Distances

Blasting and Electric Blasting Caps		Other Explosives		Inhabited Buildings Barricaded* (Feet)	Public Railway Barricaded* (Feet)	Public Highway Barricaded* (Feet)
Number Over	Number Not Over	Pounds Over	Pounds Not Over			
1,000	5,000			15	10	5
5,000	10,000			30	20	10
10,000	20,000			60	35	18
20,000	25,000		50	73	45	23
25,000	50,000	50	100	120	70	35
50,000	100,000	100	200	180	110	55
100,000	150,000	200	300	260	155	75
150,000	200,000	300	400	320	190	95
200,000	250,000	400	500	360	215	110
250,000	300,000	500	600	400	240	120
300,000	350,000	600	700	430	260	130
350,000	400,000	700	800	460	275	140
400,000	450,000	800	900	490	295	150
450,000	500,000	900	1,000	510	305	155
500,000	750,000	1,000	1,500	530	320	160
750,000	1,000,000	1,500	2,000	600	360	180
1,000,000	1,500,000	2,000	3,000	650	390	195
1,500,000	2,000,000	3,000	4,000	710	425	210
2,000,000	2,500,000	4,000	5,000	750	450	225
2,500,000	3,000,000	5,000	6,000	780	470	235
3,000,000	3,500,000	6,000	7,000	805	485	245
3,500,000	4,000,000	7,000	8,000	830	500	250
4,000,000	4,500,000	8,000	9,000	850	510	255
4,500,000	5,000,000	9,000	10,000	870	520	260
5,000,000	7,500,000	10,000	15,000	890	535	265
7,500,000	10,000,000	15,000	20,000	975	585	290
10,000,000	12,500,000	20,000	25,000	1,055	635	315
12,500,000	15,000,000	25,000	30,000	1,130	680	340
15,000,000	17,500,000	30,000	35,000	1,205	725	360
17,500,000	20,000,000	35,000	40,000	1,275	765	380
		40,000	45,000	1,340	805	400
		45,000	50,000	1,400	840	420
		50,000	55,000	1,460	875	440
		55,000	60,000	1,515	910	455
		60,000	65,000	1,565	940	470
		65,000	70,000	1,610	970	485
		70,000	75,000	1,655	995	500
		75,000	80,000	1,695	1,020	510
		80,000	85,000	1,695	1,040	520
		85,000	90,000	1,760	1,060	530
		90,000	95,000	1,790	1,075	540
		95,000	100,000	1,815	1,090	545
		100,000	125,000	1,835	1,100	550
		125,000	150,000	1,900	1,140	570
		150,000	175,000	1,965	1,180	590
		175,000	200,000	2,030	1,220	610
		200,000	225,000	2,095	1,260	630
		225,000	250,000	2,155	1,295	650
		250,000	275,000	2,215	1,330	670
		275,000	300,000	2,275	1,365	690
		300,000	325,000	2,335	1,400	705
		325,000	350,000	2,390	1,435	720
		350,000	375,000	2,445	1,470	735
		375,000	400,000	2,500	1,500	750
		400,000	425,000	2,555	1,530	765
		425,000	450,000	2,605	1,560	780
		450,000	475,000	2,655	1,590	795
		475,000	500,000	2,705	1,620	810

*Barricaded, as here used, signifies that the building containing explosives is screened from other buildings, railways, or from highways by either natural or artificial barriers. Where such barriers do not exist, the distances should be doubled.

Wisconsin Safety Orders

The Wisconsin Industrial Commission adopted in 1922 this Safety Code for Quarries, which is the most complete of that of any state and in many respects worthy of being followed by other states.

Order 358—Construction of Orders. Failure on part of superintendents, foremen, bosses and other persons having control of any place of employment, or of any employee and of any operations, to carry out any duty prescribed in these orders, is violation of such order by the employer.

Order 360—Definitions:

(a) **Application.** These orders shall apply to all quarries in the state of Wisconsin.

(b) **Singular and plural numbers.** For the purpose of these orders the singular number when used in reference to persons, acts, objects, and things of whatsoever kind and description, shall, whenever the context will permit, be taken and held to import and include the plural number, and the plural number shall similarly be taken and held to import and include the singular.

(c) **Definiton of Quarry.** The term "quarry" when used in these orders shall be held to mean a place from which stone, rock, sand, gravel, or any other material is removed from open face workings, but shall not include the removal of material in construction work.

(d) **Superintendent.** The term "superintendent" when used in these orders shall mean the person having general supervision of the quarry.

(e) **Quarry Foreman.** The term "quarry foreman" when used in these orders shall mean a person who at any one time is charged with the immediate direction of the quarry work.

(f) **Excavations or Workings.** The words "excavations" and "workings" when used in these orders shall signify all working places of a quarry, whether abandoned or in use.

(g) **Explosives.** The term "explosive" or "explosives" as used in these orders shall mean all explosive compounds commonly used in blasting practice, including the dynamites, Gelatin Dynamite, Ammonium-nitrate Dynamite, blasting powders, black powders, fuse, and all detonators.

(h) **Magazine.** The term "magazine" as used in these orders, shall be held to mean and include any building or other structure or place in which explosives are stored or kept, whether above or below ground.

(i) **Primer.** The term "primer" when used in these orders shall be held to mean a capped fuse or electric exploder inserted in a stick of powder.

(j) **Person.** The term "person" when used in these orders shall be held to mean and include a firm or body corporate as well as natural persons.

(k) **Approved.** The term "approved" shall be held to mean approved by the Industrial Commission.

Order 331—General Safety Precautions. (a) The operator and superintendent of every quarry shall use every reasonable precaution to insure the safety of the workmen in the quarry in all cases, whether provided for in these orders or not.

(b) All defects in or damage or injury to machinery or timbering or to apparatus and equipment generally in and about a quarry, and all accidents occurring in the course of quarrying operations, even though not resulting in personal injury, shall be promptly reported to the quarry foreman or superintendent by the person observing the same.

(c) Each workman employed in the quarry, when first engaged, shall have his attention directed to the general and special rules provided for in these orders, and if not able to read the English language, to have them explained to him.

(d) No person shall without authority of his foreman or superintendent handle electric wires or conductors, or electrical apparatus of any kind.

Order 362—Care of the Injured. (a) It shall be the duty of the operators, superintendents, or anyone in charge of any quarry, to keep at such places about the quarry as may be designated by the Industrial Commission, a stretcher, a woolen blanket, in good condition for use in carrying any person who may be injured at the quarry. At all quarries an adequate supply of materials shall be kept readily accessible for the treatment of anyone injured and shall include the following in suitable quantity: First-aid outfits consisting of one extra long gauze bandage with compress sewed in its center, one triangular bandage with methods of application printed thereon, two safety pins, and one card of instructions; large first-aid dressings for wounds; package of sterilized gauze; assorted bandages; United States Army tourniquet; carbolated vaseline or boric acid ointment; tincture iodine ½ U. S. P.; packages of absorbent cotton; safety pins; shears, tweezers, aromatic spirits of ammonia; paper cups; first-aid book of instructions; soaps; basins; towels.

(b) It shall be the duty of the foreman or superintendent to have at least two men employed at the quarry receive instructions from a competent person in the proper handling and treatment of injured persons before the arrival of a physician. These instructions should be received from time to time, not less than once in every six months.

Order 363—Tunnels in quarries. All tunnel work in connection with quarry operations shall be governed by the provisions of the General Orders on Safety in Mines issued by the Industrial Commission of Wisconsin.

Order 364— Superintendents. (a) The operator of every quarry shall appoint a man who shall be personally in charge of the quarry and the performance on the work done therein, who shall be designated as the "superintendent," provided, however, that nothing herein contained shall prevent tne owner or operator of any quarry from personally filling the office of superintendent.

(b) The superintendent of every quarry shall inspect or cause some competent per-

son or persons appointed by him to inspect all quarrying appliances, boilers, engines, magazines, explosives, signalling devices, tracks, ladders, dry closets, and all parts and appliances of said quarry in actual use, and any such person or persons appointed by the said superintendent shall at once report any defects therein to the superintendent. It shall be the duty of the superintendent, upon ascertaining such defects to take immediate steps to remedy the same so as to make the same comply with the provisions of these orders, and he shall forthwith notify the operator of said quarry of the existence of such defects. It shall be the duty of the superintendent to appoint a competent man to have full charge, under the direction of said superintendent of every magazine containing explosives situated on said quarrying property, and to make such other appointments and perform such other duties as are provided by these orders to be performed by such superintendent.

Order 365—Inspection at the Face of the Quarry. (a) The superintendent of the quarry or a competent person detailed for this purpose shall make frequent inspections of the face of the quarry and of the overburden where men are employed and shall dislodge any slabs of rocks or boulders in said face that may be dangerous to employes.

(b) Where necessary watchmen shall be employed at each face to warn the men in the quarry when loose rocks are about to fall.

(c) Sand and gravel pits shall be given a slope that will eliminate the danger of cave-ins based upon the experience of such pit.

Order 366—Bulletin Boards. Safety bulletin boards shall be provided by operators at all quarries. Miscellaneous rules for quarrymen, safety bulletins, pictures, slogans, or circulars shall be posted on such bulletin boards.

Order 367—Elevated Spur Tracks. Elevated spur tracks shall be kept in good condition and a bumper placed on or other means provided to prevent cars rolling over the embankment. A proper runway for car men shall be provided.

Order 370—Cables, Standards. The maximum safe working load for all hoisting cables used in quarries must be not more than one-fifth of the breaking load as given in the schedules of the manufacturers. Cables are considered unsafe and must be condemned when through broken wires, wear, rust, undue strain, or other conditions indicating deterioration, the strength of the cable has deteriorated 20 per cent.

Order 380—Hoisting Apparatus and Derricks. (a) Wire rope slings, grabhooks or chains shall be used to attach the blocks of stone to the hoisting apparatus.

(b) All ropes, chains, cables, slings, sheaves, gears and other parts of derricks and hoisting apparatus in use shall be carefully examined daily. Any parts that are found to be defective shall be renewed immediately.

(c) The wire rope guys supporting the mast of a derrick and their fastenings shall be inspected semi-monthly while in use and shall be kept in good condition.

(d) An approved signal system shall be maintained when the hoists or derricks are so located that the operator cannot readily see or hear the signals given by men near the end of the hoists or derricks.

Order 381—Hoisting Men. No person shall be hoisted out of or lowered into a quarry. Employes shall not be permitted to ride on conveyor or elevator belts.

Order 385—Explosives. (a) The daily supply of explosives in a quarry shall be kept in a stout, tight box with hinged lids and not more than one hundred pounds of explosives shall at any time be kept or stored therein, and except when necessary opened for use by authorized persons, shall at all times be kept securely locked. Upon each such magazine there shall at all times be kept conspicuously posted a sign with the words "EXPLOSIVES" "DANGEROUS" legibly printed thereon.

(b) All explosives except detonators in excess of the daily supply authorized to be taken into or stored in the quarry shall be kept or stored in an approved magazine. All magazines shall, unless otherwise authorized by the commission, be located and constructed as follows: It shall be placed not less than 300 feet distant from any other structure or public highway. It shall be constructed of bullet-proof and fire resistant material and shall have no opening except for ventilation and entrance. Doors of such magazine must be kept closed and securely locked, except when it has to be entered by the person or persons in charge thereof.

Upon each side of such magazine there shall at all times be kept conspicuously posted a sign with the words "EXPLOSIVES DANGEROUS" legibly printed.

Magazines shall be ventilated, and the openings for ventilation shall be so screened that sparks of fire may not enter therein.

Magazines shall at all times be kept clean and dry.

Magazines shall be in charge of a person especially appointed for the purpose who shall have in his possession the keys of the magazine, and shall be responsible for the safe storage of explosives contained therein.

(c) All electric wires in any magazine or thaw house shall be protected by fuses and inclosed in a grounded conduit and shall not be brought within 5 feet of the explosives stored therein. The light shall be protected with guards.

(d) No naked light shall be introduced into a magazine where powder, explosives or inflammable substance are stored.

Smoking shall not be permitted in a powder magazine, at a powder distributing station, or while handling powder.

(e) When supplies of explosives or fuse are removed from a magazine, those that have been longest in the magazine shall be taken first.

(f) Containers of explosives shall be removed to a safe distance from the magazine before being opened, and no such containers shall be opened with an iron or steel instrument.

Order 386—Storage of Detonators, Crimpers, Capping of Fuses. (a) No detonators shall be taken into any magazine containing other explosives.

No detonators shall be transported with other explosives except when being carried to the face for immediate use.

(b) All primers shall be exploded within thirty-six hours after making.

(c) Detonators shall not be removed from original containers except as they are used for capping fuses.

(d) No fuses shall be capped with detonators in any magazine or in any other place where detonators or other explosives are stored, but special benches shall be provided at a safe distance from such

storage place, where all fuses shall be capped.

(e) Only a crimper shall be used for attaching fuse to blasting caps. The quarry operator shall furnish and keep in accessible places, ready for use, crimpers in good repair. Broad jaw crimpers shall be used.

Order 387—Tamping Bars and Powder Punches. All tamping bars and powder punches shall be of wood or non-sparking metal.

Order 388—Thawing Dynamite. (a) Every quarry thawing dynamite or other high explosives containing nitro-glycerine shall not be thawed in any other place or in any other manner than as provided for in this order.

(b) Dynamite or other explosives containing nitro-glycerine shall not be thawed by any means other than indirect steam heat or a hot water device or by manure, or by electric current. If steam or water be the agent employed, the stove, boiler or other primary source of heat shall not be nearer to the thawing room than ten feet. If electric current be the thawing agent, the current shall not be brought within five feet of the explosives to be thawed; and in no case shall these explosives while being thawed be exposed to a temperature higher than ninety degrees F. The place for thawing shall be so arranged that the boxes or loose powder shall not come in direct contact with the hot water pipes or other source of heat.

(c) Dynamite or other explosives shall not be thawed by placing near a fire or near a steam boiler. Dynamite or other explosives containing nitro-glycerine shall not be thawed by direct contact with steam.

Order 389—Blasting. (a) Bosses and shot firers about to fire shots, shall cause warnings to be given in every direction, and all entrances to the place or places where charges are to be fired shall be guarded so far as possible.

(b) When firing by electricity from power or lighting wires in any quarry, a proper switch shall be furnished with lever down when "off." The switch shall be fixed in a locked box or room to which no person shall have access except the blaster. The lead wires shall be furnished with plugs and shall not be connected with the switch till ready to fire. After blasting, the switch lever shall be pulled out, the wires disconnected, and the box or room locked before any person shall be allowed to return, and shall remain so locked until again ready to blast.

(c) Special precautions shall be taken against shot firing cables or wires coming into contact with lighting, power or other circuits or with any metal pipe lines. All portable devices for generating or supplying electricity for shot firing shall be in charge of a boss or shot firer. No person other than a boss or shot firer shall connect the firing machine or battery to the shot firing leader and such connection shall not be made until all other steps preparatory to the firing of a shot shall have been completed and the men removed to a safe distance.

(d) Suitable and convenient shelters shall be provided.

Note: Wooden sheds or buildings shall not be deemed sufficient shelter from blasts.

Order 391—Overburden.. All places in quarry excavations where men are or may be regularly employed, the stripping walls of soil or overburden shall not be made continuous with the quarry walls and shall be protected either by

(1) If the stripped surface is narrow, or if it slants towards the excavation in such manner that there is a possibility of material falling over the edge a protecting fence or barrier shall be maintained along the edge of the pit, or

(2) Employees shall not be permitted to work where falls of overburden may cause injury.

Order 392—Hoisted Material. Hoisted material, or any loose material about the quarry shall be deposited not less than ten feet from the edge of the excavation and secured in such a manner that there is no possibility of the material falling back into the pit where the men are employed.

Order 393—Trimming Loose Scale. Persons engaged in trimming down loose scale and loose rock from high and steeply inclined ledges shall be provided with safety ropes. One end of the rope must be attached to the body continually and the opposite end firmly secured at the top of the bank.

Order 394—Quarry Stairs and Ladders. (a) Safe and easy access to quarry excavations shall be provided for deep quarries, stairs with numerous landings and secure handrails shall be provided.

(b) All landings and flights shall be securely braced beneath.

(c) Unsecured ladders shall not be used except for short flights as from one quarry bench to another. Ladder steps shall be notched in rather than merely spiked to the side supports and shall at all times be kept in good repair.

(d) After safe and adequate means of descent and ascent in quarry excavations have been provided for, strict rules shall be made prohibiting workmen from using any other means than those provided.

(e) Excavations shall be provided with railings at points where men are regularly employed, or where passageways, tracks, roadways or buildings adjoin such excavations.

Note: Exceptions may be made at points where stripping is being carried on and at points where material and rocks are landed after being hoisted from the pit.

Order 395—Hoists. Exposed cables, where they pass through sheaves shall be guarded.

Order 396—Quarry Cars and Haulage. All haulage equipment shall be frequently inspected and all defects properly repaired. "Rocker" or "Cradle" dump boulder cars shall be equipped with an approved locking device.

SUGGESTIONS AND RECOMMENDATIONS

It is recommended that each workman employed in the quarry shall have his attention directed by the quarry superintendent or one of his assistants to the provisions of the miscellaneous rules, which apply to quarry employes. A notice shall also be posted in a conspicuous place to the effect that quarry employes must read these rules and be governed by them.

MISCELLANEOUS RULES FOR QUARRYMEN

1. **Reporting Injuries.** In case of accident, no matter how slight, even a slight cut or break of the skin, report to your foreman at once and have it taken care of in a clean way.

2. **Loose Rocks Overhead.** When working a quarry always look out for loose rock above, which may fall and injure you. A

small rock the size of your fist, if it falls thirty feet, may kill you.

3. **Rocks Fall from Piles.** Be careful when working around piles of stone. There is always danger that a rock may become loosened and fall and strike you.

4. **Stepping on Stones.** Before stepping on a stone always look to see that it is solid. A rocking stone may cause you to lose your footing and fall and break your leg.

5. **Hoisting Stone.** In hoisting stone or grout boxes with the derrick, there is only one safe rule for the men in the quarry to follow: Don't stand under. The moment the stone or box starts to rise, get away to a safe distance. If cable is twisted by all means use the hook or lower to ground to right same.

6. **Swinging Derrick.** When working near the derrick always look out for the swinging boom. You are liable to be struck and injured by the stone or chain.

7. **Talking to Hoistmen or Signal Man.** It is always dangerous to talk to the hoistmen or signal man. Remember that if you attract their attention from their work for only a minute it may cause them to make a serious mistake and the lives of the men in the quarry may be in danger.

8. **Dragging Stone.** In dragging stone do not stand in front. The cable or hook may break and strike you.

9. **Wedging Stone.** In wedging stone apart, always insert a stone or wedge in the break before you insert your hands. When driving wedges stand in line with your break; many have been severely crushed by the stone falling sideways.

70. **Protect Your Eyes.** Paving cutters and others who work where chips and small particles fly in the air, are required to wear goggles to protect their eyes. Remember you have only two eyes and one or both may be blinded by a small chip.

11. **Walking on Tracks.** Be careful when walking on the car tracks. You are always in danger of being struck by the cars.

12. **Mushroom Heads.** Mushroom heads on chisels, points and tracers are always dangerous for the reason that when struck by the hammer a small part may be broken off and fly in the eye. Many men have lost an eye because they did not properly trim the heads of these tools.

13. **Danger at Bottom of Incline.** When the car is going up the incline of the crusher, don't follow it or stand on the track at the foot of the incline. There is always danger that the cable may break or some other part give way, and you may be struck by the car and be killed.

14. **Sledges Caught in Awning.** Paving cutters should be careful to construct the supports or frameworks for their tents high enough so that in working, the sledge hammer will not catch in the canvas and cause an accident to yourself and others.

15. **Report Dangerous Conditions.** Every man in this quarry must report to his foreman any condition or dangerous practice which he thinks may cause an accident. The only way to have a safe quarry is for every man to do his part.

16. **Compressed Air Is Dangerous.** Compressed air must not be used for cleaning clothes or for horse-play. Pointing air hose at persons has resulted in serious injuries, and is strictly forbidden.

USE OF EXPLOSIVES

The handling of explosives is dangerous business. Every man must observe the following rules

17. **Forcing Primer.** Do not force a primer into a hole.

18. **Smoking Forbidden.** Smoking while handling explosives is strictly forbidden.

19. **Use Wooden Tamping Sticks.** All Tamping bars and powder punches shall be of wood or non-sparking metal.

20. **Care of Explosives.** Fuse, caps, and powder must not be left lying about the quarry. All caps or primers or sticks or pieces of dynamite found lying about the quarry must be immediately put in a safe place.

21. **Caps Kept Separate from Dynamite.** Blasting caps must not be kept in the same box with, or close to dynamite.

22. **Don't Carry Caps in Pocket.** Don't carrying blasting caps in your pocket, and don't tap or otherwise investigate same.

23. **Removing Blasting Caps from Box.** Don't attempt to remove blasting caps from boxes by inserting nails or any sharp instrument.

24. **Use Crimper for Capping Fuses.** Only a crimper shall be used for attaching fuse to blasting caps. Do not use your teeth or knife.

25. **When Dynamite Fails to Explode.** When a blast has been fired and it is not certain that all charges have exploded, no persons shall enter the place where such charges were placed within 30 minutes after the explosion.

26. **Opening Powder Cans.** You must not open a metal keg of powder with a pick or metal object. Use the opening provided by the manufacturer of the keg.

27. **Missed Holes.** No person shall be permitted to extract, or attempt to extract, explosives from a "missed hole," but shall when possible, put in a new primer and blast again. When not possible to do this, wait for orders from the foreman.

29. **Warning for Blast.** When ready to fire shots, warnings must be given in every direction, and all entrances to the place or places where charges are to be fired shall be guarded so far as possible.

Statistics of Production

Sand and Gravel

As reported to the United States Geological Survey, the production of sand and gravel in 1921 showed a decrease of 3 per cent from 1920 but was much larger than in any other year since 1916. There was a decrease in the quantity of sand and gravel used for every purpose except filtering and paving. Filtering sand increased 24 per cent, paving sand 27 per cent, and paving gravel 38 per cent.

The total value of all the sand and gravel produced in 1921 was $56,582,624, as compared with $65,661,605 in 1920.

According to reports the producers could not supply the demand for sand and gravel in 1920 because of the car shortage, whereas in 1921 with more cars available the demand was not so great. The smaller demand, according to the reports of most producers, was due to high freight rates. As a result of the high rates many

States.	Total sand.		Total gravel.		Total sand and gravel	
	Quality.	Value.	Quality.	Value.	Quality.	Value.
Alabama	233,217	$152,546	541,399	$288,879	774,616	$381,425
Arizona	124,462	93,472	258,705	194,005	383,167	287,477
Arkansas	222,070	184,666	1,241,937	598,146	1,464,007	782,812
California	1,876,714	1,376,822	2,827,500	1,872,257	4,704,214	3,249,079
Colorado	100,603	75,647	176,680	119,075	277,283	194,722
Connecticut	258,133	117,223	77,269	63,137	335,402	180,360
Delaware	43,954	25,337	4	10	43,958	25,347
District of Columbia	(a)	(a)	(a)	(a)	(a)	(a)
Florida	119,799	67,391	40,646	29,933	160,445	97,324
Georgia	(a)	(a)	(a)	(a)	329,048	177,745
Hawaii	....	....	(a)	(a)	(a)	(a)
Idaho	43,125	23,250	223,728	83,750	266,853	107,000
Illinois	3,343,996	2,346,236	3,115,696	1,670,570	6,459,692	4,016,806
Indiana	1,723,703	850,920	3,553,801	1,930,379	5,277,504	2,781,299
Iowa	1.310,438	770,914	1,331,544	956,044	2,641,982	1,726,958
Kansas	(a)	(a)	(a)	(a)	1,082,914	647,723
Kentucky	524,205	496,707	(a)	(a)	1,356,512	963,584
Louisiana	306,103	163,728	1,515,592	1,327,678	1,821,695	1,491,406
Maine	15,291	11,683	25,593	24,676	40,884	36,359
Maryland	872,483	738,287	670,970	854,448	1,543,453	1,592,735
Massachusetts	720,844	662,179	401,110	539,262	1,121,954	1,201,441
Michigan	1,848,784	995,894	3,666,469	2,019,402	5,515,253	3,015,296
Minnesota	802,086	504,572	861,734	630,470	1,663,820	1,135,042
Mississippi	79,672	31,906	2,375,733	1,151,291	2,455,405	1,183,197
Missouri	975,570	712,627	463,503	305,698	1,539,073	1,018,325
Montana	(a)	(a)	(a)	(a)	68,377	79,812
Nebraska	663,712	276,529	355,280	252,689	1,018,992	529,218
Nevada	....	....	153,285	34,862	153,285	34,862
New Hampshire	148,973	109,845	219,589	193,631	368,562	303,476
New Jersey	2,553,291	1,734,491	1,015,489	701,807	3,568,780	2,436,298
New Mexico	24,461	18,400	302,884	150,495	327,345	168,895
New York	4,521,619	2,649,120	1,499,610	1,024,007	6,021,229	3,673,127
North Carolina	245,944	107,269	465,438	378,565	711,382	485,834
North Dakota	(a)	(a)	....	....	(a)	(a)
Ohio	2,665,436	2,394,013	2,472,840	1,666,473	5,138,276	4,060,486
Oklahoma	547,796	378,251	334,053	308,256	881,849	686,507
Oregon	(a)	(a)	(a)	(a)	1,351,425	1,079,815
Pennsylvania	4,596,982	5,674,633	2,043,352	1,926,078	6,640,334	7,600,711
Rhode Island	7,332	12,998	4,032	2,592	11,364	15,590
South Carolina	38,768	27,898	291,901	126,763	330,669	154,661
South Dakota	98,355	73,504	(a)	(a)	185,639	136,152
Tennessee	(a)	(a)	(a)	(a)	1,095,114	930,767
Texas	591,700	432,088	2,378,868	1,415,653	2,970,568	1,847,741
Utah	97.460	52,007	429,943	110,937	527,403	162,944
Vermont	36,989	13,490	1,763	250	38,752	13,740
Virginia	554,976	371,230	493,317	587,297	1,048,293	958,527
Washington	810,087	411,079	671.487	470,763	1,481,574	881,842
West Virginia	908,768	1,487,888	465,911	551,154	1,374,679	2,039.042
Wisconsin	1,308,967	743,746	1,590,842	1,039,432	2,899,809	1,783,178
Wyoming	26,660	33,000	192,314	47,929	218,974	80,929
Undistributed	2,301,426	1,744,843	2,698,243	1,845,552	153,200	145,008
	38,294,954	29,148,329	41,550,054	27,434,295	79,845,008	56,582,624

(a) Included under "Undistributed."

Sand and gravel produced and sold in the United States in 1921, by States and uses, in short tons.

	Glass sand.		Molding sand.		Building sand.		Grinding and polishing sand.	
State.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Alabama	....	....	18,904	$16,743	205,984	$130,363	....	....
Arizona	....	....	....	....	532	524	....	....
Arkansas	....	....	....	....	143,744	113,769	....	....
California	5,486	$12,721	14,949	28,075	1,522,843	1,130,207	418	$1,015
Colorado	....	....	....	....	70,178	52,832	....	....
Connecticut	....	....	587	235	210,629	106,522	....	....
Delaware	....	....	(a)	(a)	2,376	1,780	1,178	2,356
D. of Columbia	....	....	....	....	(a)	(a)	....	....
Florida	....	....	....	....	79,799	43,843	1,700	1,105
Georgia	3,904	4,489	12,605	11,364	211,707	104,694	1,500	1,095
Hawaii	....	....	....	....	....	....	....	....
Idaho	....	....	....	....	5,625	4,500	....	....
Illinois	259,889	406,632	309,180	352,857	2,015,749	1,101,105	55,615	119,648
Indiana	39,860	15,846	172,001	74,232	785,535	380,661	6,104	3,659
Iowa	....	....	13,132	10,401	887,470	524,627	3,403	2,454
Kansas	....	....	150	225	934,808	565,351	....	....
Kentucky	(a)	(a)	42,861	52,656	409,027	370,748	(a)	(a)
Louisiana	1,800	1,350	....	....	237,277	126,794	(a)	(a)
Maine	....	....	....	....	(a)	(a)	....	....
Maryland	3,000	4,800	(a)	(a)	689,524	536,701	500	165
Massachusetts	1,200	5,400	12,040	9,148	575,256	507,968	6,903	16,264
Michigan	33,424	106,886	96,545	25,576	823,791	515,338	(a)	(a)
Minnesota	....	....	13,049	12,936	579,067	351,976	3,343	11,253
Mississippi	....	....	....	....	20,251	8,751	....	....
Missouri	(a)	(a)	32,699	37,589	669,621	366,439	(a)	(a)
Montana	....	....	....	....	1,689	3,234	....	....
Nebraska	....	....	1,000	1,500	634,745	260,323	(a)	(a)
Nevada	....	....	....	....	....	....	....	....
New Hampshire	....	....	....	....	90,131	72,950	....	....
New Jersey	103,694	196,814	241,587	306,209	1,426,327	627,232	49,479	132,351
New Mexico	....	....	213	160	21,469	16,142	....	....
New York	(a)	(a)	288,354	447,481	3,818,671	1,815,086	(a)	(a)
North Carolina	....	....	....	....	155,187	70,458	....	....
North Dakota	....	....	....	....	(a)	(a)	....	....
Ohio	26,767	68,706	327,788	582,097	1,530,785	1,020,114	39,057	100,337
Oklahoma	14,200	28,400	....	....	279,233	172,937	....	....
Oregon	....	....	....	....	224,424	245,377	....	....
Pennsylvania	347,238	468,357	242,810	384,349	2,335,006	2,691,175	475,466	900,245
Rhode Island	....	....	4,648	8,968	(a)	(a)	....	....
South Carolina	....	....	....	....	29,775	23,796	....	....
South Dakota	....	....	....	....	44,184	35,184	....	....
Tennessee	(a)	(a)	30,477	56,732	397,461	347,965	5,358	5,358
Texas	13,178	24,314	160	96	486,854	345,566	....	....
Utah	....	....	....	....	85,300	45,365	....	....
Vermont	....	....	(a)	(a)	2,368	863	30,360	10,728
Virginia	11,201	29,894	9,181	11,728	324,296	233,282	(a)	(a)
Washington	....	....	140	135	662,890	314,879	....	....
West Virginia	303,130	747,845	(a)	(a)	302,833	382,869	16,294	20,558
Wisconsin	100	150	17,972	17,553	565,841	318,846	8,228	19,632
Wyoming	....	....	....	....	24,665	29,625	....	....
Undistributed	112,288	191,710	3,945	2,921	40,678	33,031	205,764	118,676
	1,280,359	2,314,314	1,906,977	2,451,966	24,565,605	16,151,792	910,670	1,466,899

(a) Included under "Undistributed."

companies shipped by water and more by truck, and many roadside pits were opened during the year.

There was a general decrease in prices of sand and gravel used for various purposes in 1921, although the prices are still higher than they were in 1919.

The production of glass sand in the United States decreased 41 per cent in 1921. Pennsylvania, West Virginia, Illinois, Missouri, and New Jersey produced 88 per cent of the total quantity of glass sand in 1921. These States are named in the order of their production. The average price per ton of the glass sand sold in Pennsylvania was $1.35, West Virginia $2.47, Illinois $1.56, New Jersey $1.90. In Massachusetts the average price was $4.50 and in Michigan $3.20.

The output of molding sand decreased 63 per cent in comparison with the production in 1920. Named in the order of their output, Ohio, Illinois, New York, Pennsylvania, New Jersey, and Indiana supplied 83 per cent of the molding sand produced. The average price per ton varied greatly in different localities. The average in Ohio was $1.78, Pennslvania $1.58, New York $1.55, New

Sand and gravel produced and sold in the United States in 1921, by States and uses, in short tons—Continued.

State	Engine sand. Quantity.	Engine sand. Value.	Paving sand. Quantity.	Paving sand. Value.	Filter sand. Quantity.	Filter sand. Value.	Fire or furnace sand. Quantity.	Fire or furnace sand. Value.
Alabama	1,000	$600	7,329	$4,840	....	....	....	....
Arizona	....	....	123,930	92,948	....	....	....	....
Arkansas	2,600	1,200	75,726	69,697	....	....	....	....
California	....	....	318,877	183,414	(a)	(a)	(a)	(a)
Colorado	21,326	17,377	8,120	5,220	....	....	....	....
Connecticut	2,084	833	11,583	4,633	33,250	$5,000	....	....
Delaware	(a)	(a)	(a)	(a)	....	....	350	$875
Dis. of Columbia	(a)	(a)	(a)	(a)	....	....	....	....
Florida	5,850	1,350	30,750	19,988	1,700	1,105	....	....
Georgia	9,057	3,741	58,944	41,059	(a)	(a)	(a)	(a)
Hawaii	....	....	....	....	....	....	....	....
Idaho	....	....	37,500	18,750	....	....	....	....
Illinois	160,464	56,969	497,772	237,335	(a)	(a)	(a)	(a)
Indiana	87,380	34,019	597,359	326,058	....	....	....	....
Iowa	37,042	23,443	288,163	160,478	16,465	9,339	....	....
Kansas	16,766	9,780	54,863	29,164	....	....	....	....
Kentucky	10,615	8,440	44,842	39,759	(a)	(a)	(a)	(a)
Louisiana	(a)	(a)	64,710	34,034	....	....	....	....
Maine	....	....	(a)	(a)	....	....	....	....
Maryland	39,115	69,915	122,895	91,388	....	....	....	....
Massachusetts	60,937	(a)	47,904	32,611	3,504	6,003	6,564	7,620
Michigan	3,508	1,201	754,011	311,341	....	....	(a)	(a)
Minnesota	9,099	3,565	187,298	104,618	7,754	18,578	1,318	896
Mississippi	(a)	(a)	(a)	(a)	....	....	....	....
Missouri	....	....	90,374	35,848	....	....	(a)	(a)
Montana	(a)	(a)	11,183	9,863	....	....	....	....
Nebraska	(a)	(a)	15,858	11,208	....	....	....	....
Nevada	....	....	....	....	....	....	....	....
New Hampshire	9,842	5,045	49,000	31,850	....	....	....	....
New Jersey	49,107	27,612	632,368	345,376	17,289	47,799	20,292	30,252
New Mexico	2,426	1,824	266	200	87	74	....	....
New York	85,575	77,934	230,883	173,519	5,772	5,574	21,240	34,600
North Carolina	3,640	1,926	87,117	34,885	....	....	....	....
North Dakota	....	....	....	....	....	....	....	....
Ohio	44,273	36,533	645,457	511,696	....	....	23,148	53,221
Oklahoma	2,900	2,043	242,958	171,721	....	....	....	....
Oregon	(a)	(a)	118,474	115,302	....	....	....	....
Pennsylvania	298,328	392,621	776,633	655,627	....	....	97,319	155,177
Rhode Island	....	....	(a)	(a)	....	....	....	....
South Carolina	(a)	(a)	(a)	(a)	....	....	....	....
South Dakota	(a)	(a)	50,120	35,963	....	....	....	....
Tennessee	10,203	7,810	78,686	90,883	....	....	....	....
Texas	26,196	13,559	63,512	47,053	....	....	....	....
Utah	11,570	6,500	....	....	....	....	....	....
Vermont	....	....	(a)	(a)	....	....	....	....
Virginia	73,634	34,889	123,174	53,097	540	1,160	(a)	(a)
Washington	6,624	2,366	129,746	83,263	....	....	....	....
West Virginia	146,257	182,307	137,832	151,419	....	....	(a)	(a)
Wisconsin	32,560	8,547	620,675	331,265	....	....	3,682	2,723
Wyoming	....	....	1,995	3,375	....	....	....	....
Undistributed	32,761	84,538	95,635	52,247	17,553	20,953	30,742	34,373
	1,302,739	1,118,487	7,529,522	4,752,995	103,914	115,585	204,655	319,797

(a) Included under "Undistributed."

Sand and gravel produced and sold in the United States, 1919-1921, by kinds, in short tons.

Kind.	1919	1920	1921
Glass sand	1,827,409	2,165,926	1,280,359
Molding sand	3,774,612	5,128,075	1,906,977
Building sand	21,969,736	26,539,365	24,565,605
Grinding and polishing sand	988,240	1,132,810	910,670
Fire or furnace sand	355,458	400,953	204,655
Engine sand	1,481,481	1,754,897	1,302,739
Paving sand	4,431,306	5,920,328	7,529,522
Filter sand	58,342	83,983	103,914
Other sands	1,083,152	649,805	490,513
Railroad ballast	8,715,842	9,081,815	8,949,274
Gravel (exclusive of railroad ballast)	25,890,829	29,183,431	32,600,780
	70,576,407	82,041,388	79,845,008

Sand and gravel produced and sold in the United States in 1921, by States and uses, in short tons—Continued.

State	Building gravel. Quantity.	Building gravel. Value.	Roofing gravel. Quantity.	Roofing gravel. Value.	Paving gravel. Quantity.	Paving gravel. Value.	Railroad ballast. Quantity.	Railroad ballast. Value.
Alabama	69,165	$98,643	1,000	$750	84,468	$29,097	386,766	$100,389
Arizona	1,125	800	......	......	257,580	193,205	......	......
Arkansas	79,635	67,644	1,050	1,550	704,580	409,220	456,672	119,732
California	1,402,671	1,175,591	4,702	7,300	791,492	575,936	628,635	113,430
Colorado	106,099	96,255	695	767	10,410	11,039	59,476	11,014
Connecticut	76,593	61,868	676	1,269	......	......	......	......
Delaware	......	......	......	......	4	10	......	......
Dis. of Columbia	......	......	......	......	(a)	(a)	......	......
Florida	......	......	......	......	40,646	29,933	......	......
Georgia	(a)	(a)	......	......	......	......	26,000	8,500
Hawaii	......	......	......	......	(a)	(a)	......	......
Idaho	28,000	11,202	......	......	195,728	72,548	......	......
Illinois	1,272,413	799,419	53,391	28,239	875,209	547,206	914,683	295,706
Indiana	671,810	411,533	15,944	13,142	1,789,304	1,093,191	1,076,743	412,513
Iowa	333,097	282,771	10,390	13,893	595,229	548,576	392,828	110,804
Kansas	19,917	9,190	150	475	25,352	26,228	(a)	(a)
Kentucky	(a)	(a)	(a)	(a)	288,633	154,106	286,671	92,190
Louisiana	414,099	496,972	......	......	1,056,526	788,463	44,967	42,243
Maine	14,967	14,556	......	......	10,626	10,120	......	......
Maryland	534,389	717,845	......	......	136,581	136,603	......	......
Massachusetts	354,479	483,360	22,243	44,152	19,096	9,293	5,292	2,457
Michigan	1,306,010	827,410	7,684	2,694	2,103,187	1,129,506	249,588	59,792
Minnesota	352,543	300,805	32,697	35,042	466,987	291,581	9,507	3,042
Mississippi	164,950	117,969	......	......	1,517,583	805,159	693,200	228,163
Missouri	357,517	218,967	1,279	830	44,210	22,888	160,497	63,013
Montana	4,986	7,184	......	......	49,731	59,095	(a)	(a)
Nebraska	(a)	(a)	(a)	(a)	338,069	248,385	14,526	2,721
Nevada	10,856	3,008	......	......	......	......	142,429	31,854
New Hampshire	43,922	98,695	......	......	165,743	90,200	9,924	4,736
New Jersey	698,929	554,449	(a)	(a)	314,952	146,030	(a)	(a)
New Mexico	43,419	25,381	(a)	(a)	6,151	3,618	(a)	(a)
New York	1,199,441	776,861	2,114	2,735	234,126	217,494	63,929	26,917
North Carolina	106,135	151,609	......	......	104,190	127,056	255,113	99,900
North Dakota	......	......	......	......	......	......	......	......
Ohio	683,841	574,148	41,981	32,324	903,809	717,980	843,209	342,021
Oklahoma	162,694	129,319	......	......	169,595	177,937	(a)	(a)
Oregon	195,897	162,725	(a)	(a)	640,272	492,576	147,812	36,890
Pennsylvania	1,068,851	1,097,768	......	......	957,125	814,799	17,376	13,511
Rhode Island	3,426	1,657	(a)	(a)	(a)	(a)	......	......
South Carolina	29,417	17,650	......	......	121,316	59,709	141,168	49,404
South Dakota	(a)	(a)	......	......	(a)	(a)	31,426	5,589
Tennessee	151,214	123,575	(a)	(a)	360,676	254,140	(a)	(a)
Texas	697,520	579,060	11,756	14,730	717,474	464,540	952,118	357,323
Utah	107,997	48,037	......	......	49,600	21,780	272,346	41,120
Vermont	282	40	......	......	1,481	210	......	......
Virginia	321,696	433,610	500	1,125	127,594	128,456	43,527	24,106
Washington	160,950	116,950	630	450	413,739	328,110	96,168	25,253
West Virginia	256,714	312,704	......	......	209,197	238,450	......	......
Wisconsin	345,050	234,693	9,438	7,236	1,189,469	777,956	46,885	19,547
Wyoming	23,970	9,018	......	......	3,598	5,742	164,746	33,169
Undistributed	307,136	267,687	10,482	13,315	96,818	106,482	315,047	151,947
	14,183,822	11,918,628	228,802	222,018	18,188,156	12,364,653	8,949,274	2,928,996

(a) Included under "Undistributed."

Molding sand produced and sold in the United States, 1916-1921.

Year.	Short tons.	Value. Total.	Value. Average.
1916	4,662,649	$3,219,839	$0.69
1917	4,660,968	4,303,809	.92
1918	4,910,178	5,121,865	1.04
1919	3,774,612	4,153,990	1.10
1920	5,128,075	7,504,759	1.46
1921	1,906,977	2,451,966	1.29

Glass sand produced and sold in the United States, 1916-1921.

Year.	Short tons.	Value. Total.	Value. Average.
1916	2,018,317	$1,957,797	$0.97
1917	1,942,675	2,685,014	1.38
1918	2,172,887	4,209,728	1.94
1919	1,827,409	3,593,371	1.97
1920	2,165,926	4,748,690	2.49
1921	1,280,359	2,314,314	1.81

Jersey $1.27, Illinois $1.14, and Indiana 43 cents.

More than 490,000 tons of sand was reported as sold for uses other than those specified in the following tables. Of this quantity over 28,000 tons was sold for fertilizer filler, at an average price of $1.55. About 17,000 tons was sold for bedding stock cars, at a price of 42 cents. A small quantity is reported each year as sold for standard testing sand.

The value of the sand exported in 1921 showed a decrease of 43 per cent as compared with 1920. Canada receives most of the sand exported, and the value of that shipped to Canada in

Average price per short ton of sand and gravel produced and sold in the United States, 1917-1921.

[Based on prices realized for sales f. o. b. pits or nearest shipping points.]

Kind.	1917	1918	1919	1920	1921
Glass sand	$1.38	$1.94	$1.97	$2.19	$1.81
Molding sand	.92	1.04	1.10	1.46	1.29
Building sand	.39	.50	.56	.68	.66
Grinding and polishing sand	1.04	1.60	1.34	1.80	1.61
Fire or furnace sand	1.15	1.48	1.23	1.81	1.56
Engine sand	.59	.76	.77	.82	.86
Paving sand	.41	.54	.66	.68	.63
Filter sand	.76	1.47	1.48	1.27	1.11
Railroad ballast	.17	.22	.30	.32	.33
Gravel (exclusive of railroad ballast)	.46	.57	.66	.81	.75
All kinds	.46	.61	.65	.80	.71

Value of sand and gravel exported from the United States in 1919-1921.

Destination	1919	1920	1921
Canada	$347,578	$583,574	$247,895
Mexico	14,803	38,402	97,342
Panama	4,650	13,307	8,600
Japan	3,091	6,758	4,072
England	967	6,161	3,718
Cuba	2,438	10,746	7,285
Newfoundland	279	1,418	854
Brazil	40	66	622
China	130	833	1,301
Argentina	712	58	....
Other countries	7,382	8,622	8,293
	$382,070	$669,945	$379,982

Sand imported for consumption in United States, 1919-1921.

Year.	Short tons.	Value. Total.	Value. Average.
1919	597,481	$126,586	$0.21
1920	1,226,684	912,282	.74
1921	906,905	771,734	.85

1921 was less than half that shipped in 1920. The increase in the value of the sand shipped to Mexico in 1921 was 153 per cent. It is not known for what purposes the exported sand was used.

A considerable quantity of the sand imported is brought into the country as ballast; a certain quantity is building sand brought in from Pelee Island, which is across the Canadian boundary in Lake Erie. White sand is imported from Belgium for the glass-making industry on the Pacific coast.

LIME IN 1922.

About 3,528,000 short tons of lime, valued at $33,057,000, was sold in the United States, including Hawaii and Porto Rico, in 1922, according to an estimate made by the United States Geological Survey, from reports received from the principal producers. This quantity is more than 39 per cent greater than that sold in 1921 and only 1 per cent less than that sold in

Lime produced in the United States in 1921 *and* 1922 *(estimated).*

State	1921 Hydrated lime (Short tons)	1921 Total lime Short tons	1921 Total lime Value	1922 (estimated) Hydrated lime (Short tons	1922 (estimated) Total lime Short tons	1922 (estimated) Total lime Value
Ohio	346,669	471,053	$ 4,224,579	536,000	717,000	$ 6,700,000
Pennsylvania	135,917	509,891	4,247,509	170,000	700,000	5,521,000
Missouri	45,903	159,194	1,656,560	58,000	201,400	2,017,000
Wisconsin	15,411	124,078	999,407	21,570	187,100	1,524,500
West Virginia	38,335	119,716	1,015,690	44,650	178,000	1,515,000
Alabama	7,030	109,256	847,629	15,500	165,000	1,284,000
Virginia	11,159	111,518	1,005,677	16,000	156,000	1,250,000
Massachusetts	(a)	124,183	1,890,512	(a)	156,000	1,997,000
Tennessee	25,719	93,397	733,639	31,600	129,000	1,008,000
Maine	(a)	90,585	1,392,850	(a)	127,300	1,892,000
Indiana	29,605	90,542	826,311	46,000	117,800	1,084,000
New York	(a)	67,685	759,299	(a)	105,000	981,000
Illinois	11,034	58,222	610,197	12,700	76,700	837,000
Maryland	33,553	64,835	558,785	43,000	70,000	550,000
California	(a)	42,115	577,366	(a)	60,000	743,000
Texas	19,634	44,404	452,078	20,770	52,000	505,000
Michigan	(a)	48,164	445,386	(a)	50,000	430,000
Connecticut	(a)	(a)	(a)	(a)	(a)	(a)
Vermont	(a)	32,782	460,318	(a)	46,200	513,000
Minnesota	(a)	22,109	232,037	(a)	27,200	249,000
Washington	(a)	17,710	209,761	(a)	25,500	302,000
Undistributed	73,001	130,714	1,713,780	109,510	180,800	1,954,500
	792,970	2,532,153	$24,859,370	1,125,300	3,528,000	$33,057,000

a Included in undistributed.

Lime sold in the United States in 1920 *and* 1921, *by States.*

State.	Rank of State by quantity.	Short tons.	Percentage of total quantity.	Value.	Rank of State by value.	Average value per ton.	Number of plants in operation.
Alabama	8	109,256	4.3	$847,629	9	$7.76	10
Arizona	22	11,783	.5	162,647	22	13,80	3
Arkansas	24	8,958	.3	93,499	25	10.44	3
California	17	42,115	1.7	577,366	15	13.71	7
Colorado	28	5,783	.2	56,956	28	9.85	3
Connecticut	18	(a)	(a)	(a)	13	16.66	5
Florida	23	(a)	(a)	(a)	23	11.93	2
Georgia	27	(a)	(a)	(a)	27	9.71	1
Hawaii	35	1,985	.1	50,690	29	25.54	1
Idaho	41	(a)	(a)	(a)	39	15.07	1
Illinois	14	58,222	2.3	610,197	14	10.48	12
Indiana	11	90,542	3.6	826,311	10	9.13	8
Iowa	29	(a)	(a)	(a)	30	8.67	2
Kentucky	39	1,524	.1	11,551	41	7.58	3
Maine	10	90,585	3.6	1,392,850	5	15.38	4
Maryland	13	64,835	2.6	558,785	16	8.62	17
Massachusetts	4	124,183	4.9	1,890,512	3	15.22	10
Michigan	15	48,164	1.9	445,386	19	9.25	6
Minnesota	20	22,109	.9	232,037	20	10.50	5
Missouri	3	159,194	.3	1,650,560	4	10.41	17
Montana	38	(a)	(a)	(a)	37	13.40	2
Nevada	31	(a)	(a)	(a)	31	10.64	1
New Jersey	37	1,818	.1	14,365	40	7.90	7
New Mexico	32	3,044	.1	33,660	34	11.06	4
New York	12	67,685	2.7	759,299	11	11.22	16
North Carolina	26	(a)	(a)	(a)	26	10.00	1
Ohio	2	471,053	18.6	4,224,579	2	8.97	31
Oklahoma	34	(a)	(a)	(a)	38	9.98	2
Oregon	40	(a)	(a)	(a)	36	21.44	1
Pennsylvania	1	509,891	20.1	4,247,509	1	8.33	183
Porto Rico	33	2,740	.1	44,113	33	16.10	23
Rhode Island	36	(a)	(a)	(a)	35	17.63	1
South Dakota	30	(a)	(a)	(a)	32	10.34	2
Tennessee	9	93,397	3.7	733,639	12	7.86	17
Texas	16	44,404	1.7	452,078	18	10.18	8
Utah	25	7,972	.3	104,605	24	13.12	10
Vermont	19	32,782	1.3	460,318	17	14.04	9
Virginia	7	111,518	4.4	1,005,677	7	9.02	36
Washington	21	17,710	.7	209,761	21	11.84	7
West Virginia	6	119,716	4.7	1,015,690	6	8.48	13
Wisconsin	5	124,078	4.9	999,407	8	8.05	24
Wyoming	42	(a)	(a)	(a)	42	20.98	2
Undistributed	..	85,107	3.3	1,177,694	..	....	...
		2,532,153	100.0	24,895,370		9.83	520

a Included under "Undistributed."

Lime sold in the United States in 1921, *by uses.*

Use	Percentage of total quantity	Short tons	Value Total	Value Average
Building	49.0	1,239,486	$13,258,443	10.70
Agricultural	11.2	284,722	2,237,510	7.86
Chemical:				
Paper mills	9.3	235,855	2,207,938	9.36
Glass works	1.7	43,851	367,796	8.39
Sugar factories	.5	12,225	161,931	13.25
Tanneries	1.9	47,841	481,372	10.06
Metallurgy	6.5	164,245	1,232,748	7.51
Other uses	18.0	456,087	4,372,991	9.59
Total chemical	37.9	960,104	8,824,776	9.19
Dealers	1.9	47,841	574,641	12.01
	100.0	2,532,153	24,895,370	9.83
Hydrated lime (included in totals)	...	792,970	7.421,637	9.36
Percentage of decrease of hydrated lime in 1921	...	7	20	14

Different kinds of agricultural lime sold in 1919-1921

	Short tons		Value	
	Gross	Effective lime content	Total	Average
1919				
Lime from:				
Limestone—				
Quicklime	240,467	202,000	$1,560,929	$6.49
Hydrated	198,165	138,700	1,784,110	9.00
Oyster shells	34,251	28,800	364,202	10.63
Limestone (pulverized)	1,392,914	599,000	2,409,460	1.73
Calcareous marl	91,437	40,600	327,294	3.58
1920				
Lime from:				
Limestone—				
Quicklime	202,870	170,400	1,570,755	7.74
Hydrated	148,981	104,300	1,525,950	10.24
Oyster shells	38,506	32,300	311,695	8.09
Limestone (pulverized)	1,364,260	587,000	2,724,209	2.00
Calcareous marl	97,487	42,000	322,339	3.31
1921				
Lime from:				
Limestone—				
Quicklime	142,140	119,400	940,318	6.62
Hydrated	142,582	99,800	1,297,192	9.10
Oyster shells	24,315	20,400	197,092	8.11
Limestone (pulverized)	1,311,520	564,000	2,355,339	1.80
Calcareous marl	59,730	25,700	195,743	3.28

Hydrated lime sold in the United States in 1920 and 1921, by uses.

Use	1920		1921	
	Short tons	Value	Short tons	Value
Building	562,153	$6,220,895	539,550	$4,996,718
Agriculture	148,981	1,525,950	142,582	1,297,192
Chemical:				
Paper mills	7,237	87,382	4,840	48,270
Sugar factories	4,111	42,131	4,633	38,628
Tanneries	14,828	163,941	14,872	153,336
Glass factories	3,232	36,529	1,299	12,934
Metallurgy	1,521	16,198	2,453	21,921
Other uses	85,819	951,841	69,612	718,285
Total chemical	116,748	1,298,022	97,709	993,374
Dealers	25,234	242,695	13,129	134,353
	853,116	9,287,562	792,970	7,421,637

Lime exported from the United States, 1919-1921.

Year	Short tons	Value	
		Total	Average
1919	6,372	$108,370	$17.01
1920	5,921	128,296	21.67
1921	5,192	109,769	21.14

Lime sold in the United States in 1919-1921.

Year.	Short tons.	Value. a		Number of plants in operation.
		Total.	Average.	
1919	3.330,347	$29,448,553	$8.84	539
1920	3,570,141	37,543,840	10.52	515
1921	2,532,153	24,895,370	9.83	591
Percentage of increase or decrease in 1921	—29	—34	—6.6	+1

a The value given represents the value of bulk lime f. o. b. at point of shipment and does not include cost of barrel or package.

1920. The average value per ton in 1922 is estimated at $9.37. In 1921 it was $9.83 and in 1920 it was $10.52. Of the 42 States and Territories that produced lime in 1922, 5 showed a decrease and 37 an increase in output as compared with 1921. This showing is in marked contrast with that for 1921, when the output of 34 States decreased and that of only 8 increased. The states that showed decrease in 1922 are all small producers of lime and serve markets that are largely influenced by local demand.

The sales of hydrated lime in the United States in 1922 were estimated at 1,125,300 short tons, an increase of 42 per cent over those in 1921 and the largest yet reported. Of the 31 States that reported an output of hydrated lime in 1922 only three showed a decrease. The estimated value of the hydrated lime sold in 1922 was $10,850,000, an average value per ton of $9.64. The average value in 1921 was $9.36.

Reports indicated that about the same number of plants were in operation in 1922 as in 1921, but some of the small plants from which no reports were received may have shut down on account of the scarcity and the high cost of coal. The use of wood to help conserve coal was noted by the manufacturers. It is noticeable, however, that farmers who had not burned lime for several years started their kilns again in 1921 and 1922 and burned small quantities in field kilns, as the lime so made was cheaper than that which could be bought in the market. Labor appeared to be plentiful, but cars for transportation were not always available. The demand for lime was obviously better in 1922 than in 1921, but producers report that the market was very irregular. Prices fluctuated greatly throughout the year, but showed a decided downward trend. Lime for construction undoubtedly made the largest increase in production, and chemical lime also increased appreciably, but it is doubtful whether agricultural lime made any increase whatever.

Though a few producers reported that the demand for construction lime was the same as in 1921, or even less, the greater number reported a much better demand and increases ranging from 3 to 75 per cent. Some reported increases of 100 to 200 per cent. Most producers reported, that the first ten months of the year was the time of greatest demand; others reported a poor market early in the year and improvement late in the summer and in the fall. The average prices in some States were higher and in others lower than in 1921, but the average for the country was doubtless lower.

Chemical lime showed decided improvement in demand during the year, according to the manufacturers of lime of this class, but not so decided an improvement as construction lime. Though increases of 5 to 70 per cent and exceptionally of 125 and 160 per cent were reported there were more reports of fair demand and about the same demand as in 1921 than in the reports for construction lime. The last half of the year appeared to be a time of great improvement in the chemical lime trade in 1922. The sales of refractory lime (dead-burned dolomite), used in patching and lining basic open hearth furnaces, increased from 107,664 short tons in 1921 to over 300,000 tons in 1922.

Magnesite.

Reports received by the United States Geological Survey, Department of the Interior, from producers of magesite show that the quantity of crude magnesite sold or treated during the calendar year 1921 was 47,904 short tons, valued at the mines at $510,177. This quantity was less than half that for the year 1920, and smaller than that for any year since 1916. California was the only producing state, and nearly all the product was calcined for use as plastic material. The output of domestic magnesite for use in refractory products was very small.

In contrast to the large decrease in domestic production there was an increase in imports, which consisted chiefly of crude magnesite. The apparent consumption of magnesite in the United States in 1921 was equivalent to about 113,500 short tons of crude magnesite, 58 per cent of which was imported. This consumption is the lowest recorded for many years, probably largely because of conditions in the metallurgic industries, which consume in the form of refractory material, most of the magnesite used.

Pyrites.

The production of pyrites in 1920, as compiled from figures collected by the United States Geological Survey, was 310,777 long tons, valued at approximately $1,597,000. This quantity was almost twice that produced in 1921—157,118 long tons—estimated to be worth about $700,000. In 1920 California led in production, contributing 128,114 long tons, which was only a few hundred tons less than in 1919, and 98,252 long tons in 1921. The average value per ton for the total pyrites produced in the United States was somewhat less in 1921 than in 1920, being about $5 for 1920 and $4.45 for 1921.

The reports received from producers indicate that the market for pyrites has been very poor for the last two years, because the manufacturers of sulphuric acid, who have heretofore been the principal purchasers of pyrites, are now using more native sulphur, which is not only cheaper but more easily handled. The slack market is also reflected in the imports of pyrites (reported by the Bureau of Foreign and Domestic Commerce), which fell off about one-third in 1921 from those in 1920. The imports in 1920 amounted to 332,606 long tons, valued at $1,660,832. About 200,000 long tons came from Spain, 100,000 long tons from Canada, and small quantities from France, Cuba, Chile and Hongkong. The imports in 1921 amounted to 216,229 long tons, valued at $818,852. The price per ton of the imported ore was about $1 less in 1921 than in 1920.

Grindstones and Pulpstones.

The output of grindstones and pulpstones in the United States in 1921 amounted to 26,340 tons, valued at $1,227,322, according to figures reported by the producers to the United States Geological Survey, Department of the Interior. This was a decrease from the output in 1920 of over 50 per cent in quantity and of 28 per cent in value.

The grindstones produced amounted to 16,310 short tons, valued at $477,-259, a decrease of 63 per cent in quantity and 61 per cent in value.

The pulpstones produced amounted to 10,030 short tons (2,940 pieces), valued at $750,063, an increase of 16 per cent in quantity and 63 per cent in value. The demand at paper mills, which were very active late in 1920 and early in 1921, and which during and after the war could not renew their supply of English stone, increased the market for domestic pulpstones. If the depression that has followed this activity continues there will probably be a considerable decrease in the output of pulpstones in 1922.

The imports of grindstones and pulpstones were valued at $81,880 as against $77,046 in 1920. The exports of grindstones were valued at $281,-976 as against $424,322 in 1920.

Slate.

Slate sold in the United States in 1921, by States and uses.

State.	Operators.	Roofing Slate.			Structural and sanitary.		Electrical.		Other uses.	Total.
		Squares (100 sq. ft.)	Value.	Average value.	Square feet.	Value.	Square feet.	Value.		
Georgia.	1	....	....	......	....	....	....	....	(a)	(a)
Maine.	3	3,633	$47,916	$13.19	....	....	417,723	$358,547	$2,840	$409,303
Maryland. . .	2	(a)	(a)	10.84	....	....	....	....	(a)	(a)
New Jersey. .	1	(a)	(a)	11.00	....	....	....	....	....	(a)
New York. .	15	4,100	59,106	14.42	....	....	....	....	457,850	516,956
Penns'vania .	47	202,605	1,565,109	7.72	1,646,483	$600,753	337,186	216,271	1,213,253	3,595,386
Tennessee. . .	1	....	....	......	....	....	....	....	(a)	(a)
Vermont.	32	115,019	1,286,529	11.19	59,838	41,779	418,744	353,133	665,537	2,346,978
Virginia.	4	20,318	212,943	10.48	....	....	....	....	....	212,943
Undist'buted	...	2,410	26,142	......	....	....	....	....	214,298	240,440
	106	348,085	3,197,745	9.19	1,706,321	642,532	1,173,653	927,951	2,553,778	7,322,006
Total 1920.	99	396,230	3,524,658	8.90	2,593,563	916,216	1,950,397	1,491,769	2,793,799	8,726,442

a Undistributed includes Georgia, Maryland, New Jersey and Tennessee.

Explosives.

The figures tabulated herein are classified as follows:

1. *Black blasting powder.* — All black powder with sodium or potassium nitrate as a constituent is here classified as black blasting powder.

2. *High explosives.*—Dynamite and all other high explosives of various trade names and compositions, except permissible explosives, are put in this class.

3. *Permissible explosives.*—In this class are included ammonium nitrate explosives, hydrated explosives, organic nitrate explosives, and certain nitroglycerin explosives containing an excess of free water or carbon. All permissible explosives have passed certain tests of the Bureau of Mines and are not to be regarded as permissible unless used in the manner specified by the bureau.

	1920			1921		
	Black blasting powder.	High explosives other than permissible.	Permissible explosives.	Black blasting powder.	High explosives other than permissible.	Permissible explosives.
	Kegs.	Pounds.	Pounds.	Kegs.	Pounds.	Pounds.
Quantity used for:						
Coal mining	8,790,505	37,273,255	45,222,130	5,613,435	34,231,542	38,055,650
Other mining	347,223	89,132,316	3,750,585	184,792	50,977,366	881,710
Railway and other construction work	196,172	15,052,068	266,505	163,688	18,317,333	262,545
All other purposes	861,293	87,653,905	4,723,621	438,935	67,426,161	1,933,946
Total	10,195,193	229,112,084	53,962,841	6,400,850	170,952,402	41,133,851

Gypsum.

Gypsum produced in the United States, 1916-1921.

Year.	Crude mined (short tons).	Crude and calcined sold (total value).
1916	2,757,730	$7,959,032
1917	2,696,226	11,116,452
1918	2,057,015	11,470,854
1919	2,420,163	15,727,907
1920	3,129,142	24,533,065
1921	3,050,984	23,700,290

Gypsum imported into the United States comes almost wholly from Nova Scotia and New Brunswick and enters the ports of New England and other North Atlantic States.

Calcareous Marl.

The output of calcareous marl in the United States in 1921 amounted to 53,730 short tons, valued at $183,743, according to reports made by the producers to the United States Geological Survey, Department of the Interior. The quantity decreased 45 per cent and the value 43 per cent as compared with 1920. In 1920 the average value per ton was $3.42; in 1920 it was $3.31. Nearly all the calcareous marl sold in the United States in 1921 was used for liming the soil. Some was used as a filler in patent fertilizers. More than 63 per cent of the total output—33,978 short tons—was produced in Virginia and was valued at $105,821.

Gypsum imported and entered for consumption in the United States, 1917-1921.

Year.	Unground.		Ground or calcined.		Value of manufactured plaster of Paris.	Keenes cement.		Total Value.
	Short tons.	Value.	Short tons.	Value.		Short tons.	Value.	
1917	240,269	$265,504	16,533	$109,732	$6,016	484	$8,003	$389,255
1918	50,653	55,004	6,117	70,028	1,765	111	2,259	129,056
1919	171,733	211,946	10,415	126,405	7,719	187	5,984	352,054
1920	282,486	397,942	14,921	179,191	10,282	202	5,338	592,753
1921	266,796	364,318	4,495	55,109	33,072	184	6,836	459,335

Silica.

Silica of the kinds considered in this report is used in the manufacture of wood filler, pottery, paints, and scouring soaps, as a polisher, as foundry mold wash, in metallurgic and chemical processes, and for cosmetics and dentifrices.

Silica sold for pottery, paints, fillers, polishers, abrasives, and other uses in the United States, 1919-1921.

Material.	1919		1920		1921	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
Quartz, (vein quartz, pegmatite, and quartzite)	63,332	$373,571	68,190	$320,350	11,252	$84,957
Sand and sandstone	47,277	288,890	158,395	1,183,014	105,887	802,450
Tripoli (ground and otherwise prepared)	24,292	181,541	40,233	469,677	12,340	213,013
Diatomaceous earth	42,642	531,960	61,922	1,079,693	55,134	682,616
	177,543	1,375,962	328,740	3,152,734	184,613	1,783,036

Quartz sold in the United States, 1917-1921.

Year.	Crude.		Ground.		Total.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
1917	126,575	$120,856	16,098	$197,213	142,673	$318,069
1918	61,008	121,888	10,732	137,442	71,740	259,330
1919	51,774	135,187	11,558	238,384	63,332	373,571
1920	59,423	142,397	8,767	177,953	68,190	320,350
1921	8,570	39,660	2,682	45,297	11,252	84,957

The sales of quartz from pegmatite dikes, veins, and quartzite in 1921 showed a decrease of 83 per cent in quantity in comparison with 1920. The prices of crude quartz in 1921 ranged from $1 to $7.50 a ton and averaged $4.63. Prices of ground quartz ranged from $11 to $39 and averaged $16.89. Production was reported in California, Connecticut, Maryland, Michigan, New York, Illinois, North Carolina, Pennsylvania, Washington and Wisconsin.

Graphite.

Graphite was produced at 8 plants in 1921, as compared with 17 in 1920, 20 in 1919, and 42 in 1918. The plants producing in 1921 were in Alabama, California, Colorado, Nevada, New York, Rhode Island and Texas. The figures of production and value for the years 1915 to 1921 are:

Year.	Amorphous.		Crystalline.		Total.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
1915.	1,181	$12,358	3,537	$417,273	4,718	$429,631
1916.	2,622	20,723	5,466	914,748	8,088	935,471
1917.	8,301	73,481	5,292	1,094,398	13,593	1,167,879
1918.	6,560	69,455	6,431	1,454,799	12,991	1,524,254
1919.	3,379	47,716	4,043	731,141	7,422	778,857
1920.	4,694	49,758	4,816	576,444	9,510	626,202
1921.	1,842	20,860	595	75,664	2,437	96,524

In 1921 the price of domestic flake graphite ranged from 2 to 13 cents a pound; in 1920 from 1.75 to 13 cents. The average price of domestic flake at the mines was 6.4 cents in 1921, which was 0.5 cent more than in 1920.

Phosphate Rock.

Phosphate rock mined and sold in the United States 1920-1921, *by States.*

State.	1920		1921	
	Lon tons.	Value.	Lon tons.	Value.
Florida:				
Hard rock	400,249	$4,525,191	175,774	$1,806,671
Soft rock	13,952	190,551	4,419	20,153
Land pebble	2,955,182	14,748,620	1,599,835	8,604,818
	3,369,384	19,464,362	1,780,028	10,431,642
South Carolina:				
Land rock	44,141	367,209	....	....
Tennessee:				
Brown rock	a 556,177	4,425,761	a 252,543	1,666,358
Blue rock	78,671	518,234	25,163	146,198
	a 634,848	4,943,995	a 277,706	1,812,556
Western States b	55,609	304,006	6,291	25,872
	4,103,982	25,079,572	2,064,025	12,270,070

a Includes brown rock from Kentucky; b 1920: Idaho and Utah; 1921: Idaho and Montana.

Phosphate rock exported from the United States, 1919-1921.

Kind.	1919		1920		1921	
	Lon tons.	Value.	Long tons.	Value.	Long tons.	Value.
Phosphate rock, ground or unground, not acidulated;						
High-grade rock	215,039	$2,261,852	344,896	$4,496,457	182,594	$2,592,541
Land pebble	128,860	904,308	693,355	5,593,814	544,425	4,627,875
All other	34,832	401,822	31,461	479,904	6,293	99,721
	378,731	3,567,982	1,069,712	10,570,175	733,312	7,320,137

Phosphate rock sold in the United States, 1911-1921.

Year	Long tons.	Value f.o.b. mines.
1911	3,053,279	$11,900,693
1912	2,973,332	11,675,774
1913	3,111,221	11,796,231
1914	2,734,043	9,608,041
1915	1,835,667	5,413,449
1916	1,982,385	5,896,385
1917	2.584,287	7,771,084
1918	2,490,760	8,214,463
1919	2,271,983	11,591,268
1920	4,103,982	25,079,572
1921	2,064,025	12,270,070

Raw phosphate rock sold for direct application to the soil, 1914-1921.

	Long tons.
1914	48,317
1915	50,468
1916	70,233
1917	75,861
1918	45,294
1919	79,189
1920	72,802
1921	13,503

Fuller's Earth.

Domestic fuller's earth marketed in the United States, 1916-1921.

Year.	Number of operators.	Short tons.	Value.	Average value.
1916	10	67,822	$706,951	$10.42
1917	11	72,567	772,087	10.64
1918	14	84,468	1,146,354	13.57
1919	10	106,145	1,998,829	18.83
1920	12	128,487	2,506,189	19.51
1921	12	105,609	1,973,848	18.69

Fuller's earth imported and entered for consumption in the United States, 1916-1921.

Year.	Short tons.	Value.	Average value.
1916	16,801	$139,664	$8.31
1917	16,994	176,417	10.38
1918	12,607	165,535	13.13
1919	13,873	189,711	13.67
1920	19,235	221,893	11.54
1921	9,744	119,415	12.26

Crushed Stone sold in the United States in 1921, *by States and uses.*

State.	Concrete and road metal. Short tons.	Value.	Railroad ballast. Short tons.	Value.	Total. Short tons.	Value.
	36,765,790	45,338,984	6,437,050	6,378,494	43,202,840	51,717,478
Alabama	80,050	$87,377	....	....	80,050	$87,377
Arizona	88,660	144,614	....	....	88,660	144,614
Arkansas	644,780	718,100	34,530	$50,598	679,310	768,698
California	3,363,070	3,211,432	213,800	218,590	3,576,870	3,430,022
Colorado	a1,720	a4,276	(b)	(b)	11,030	18,926
Connecticut	1,180,460	1,257,821	30,850	31,779	1,211,310	1,289,600
Delaware	(b)	(b)	....	....	(b)	(b)
Florida	a389,840	a271,849	156,460	142,102	a546,300	a413,951
Georgia	148,350	235,864	19,010	35,655	167,360	271,519
Hawaii	165 680	364,710	....	....	165,680	364,710
Idaho	227,510	397,808	....	....	227,510	397,808
Illinois	2,459 940	2,668,845	534,170	500,846	2,994,110	3,169,691
Indiana	1,711,510	1,733,698	171,790	153,619	1,883,300	1,887,317
Iowa	299 890	379,913	(b)	(b)	a299,680	a379,913
Kansas	287,340	449,140	18,460	26,261	305,800	475,401
Kentucky	a790,720	a988,753	695,320	552,404	a1,486,040	a1 541,157
Louisiana	(b)	(b)	....	....	(b)	(b)
Maine	(b)	(b)	(b)	(b)	a4,250	a7,799
Maryland	508,310	852,070	202,250	285,923	710,560	1,137,993
Massachusetts	1,172,110	1,777,368	14,450	19,200	1,186,560	1,796,568
Michigan	1,344,160	996,711	37,090	28 752	1,381,250	1,025,463
Minnesota	490,760	743,814	....	....	490,760	743,814
Missouri	922,040	1,372,089	43,730	'58,930	965,770	1,431 021
Montana	11,980	17,835	(b)	(b)	a11,980	a17,835
New Hampshire	3,750	6,680	....	....	3,750	6,680
Nebraska	95,000	140,015	....	....	95,000	140,015
New Jersey	1,227,600	2,038,865	170,380	241,681	1,397,980	2,280,546
New Mexico	....	....	(b)	(b)	(b)	(b)
New York	4,274,800	5,498,570	609,290	630,948	4,884,090	6,129,518
North Carolina	543,610	943,875	(b)	(b)	a543,610	a943,875
Ohio	4,729,970	4,741,487	747,140	659,852	5,477,110	5,401,339
Oklahoma	495,450	593,847	353,090	337,500	848,540	931,347
Oregon	a698,810	a983,243	(b)	(b)	755,390	1,002,791
Pennsylvania	3,539,800	5,262,034	713,290	929,281	4,253,090	6,191,315
Porto Rico	71,550	108,125	3,780	4,903	75,330	113,026
Rhode Island	112,320	284,318	....	....	112,320	284,318
South Carolina	309,820	568,511	(b)	(b)	c309,820	c568,511
South Dakota	161,420	280,621	(b)	(b)	c161,420	c280,621
Tennessee	552,760	649,338	245,450	238,515	798,210	887,853
Texas	a547,170	a584,773	a237,330	a188,050	a784,500	a772,823
Utah	(b)	(b)	(b)	(b)	(b)	69,900
Vermont	a4,700	a4,380	....	....	a4,700	a4,380
Virginia	627,110	840,007	571,650	470,233	1,198,760	1,310,240
Washington	442,080	549,511	3,810	3,500	445,890	553,011
West Virginia	371,180	457,181	a245,280	a195,105	a596,620	a613,909
Wisconsin	a1,425,420	a1,726,669	(b)	(b)	a1,425,420	a1,726,669
Wyoming	....	....	(b)	(b)	(b)	(b)
Undistributed	242,590	402,847	364,650	374,267	489,340	703,594

a Output of certain kinds of stone included under "Undistributed" to conform to previous tables.

b Included under "Undistributed."

c Exclusive of railroad ballast, which is included under "Undistributed."

Crushed stone sold in the United States in 1920 *and* 1921.

	Road metal and concrete. Short tons.	Value.	Railroad ballast. Short tons.	Value.	Total. Short tons.	Value. Total.	Average.
1920.							
Granite	2,415,480	$4,240,699	601,480	$591,077	3,016,960	$4,831,776	$1.60
Basalt and related rocks (trap rock)	7,897,300	10,540,201	984,210	1,260,282	8,881,510	11,800,483	1.33
Limestone	20,419,130	25,249,446	5,388,670	5,359,353	25,807,800	30,608,799	1.60
Sandstone	944,740	1,551,429	449,530	492,192	1,394,270	2,043,621	1.47
Miscellaneous	1,147,250	1,453,255	118,070	108,759	1,265,320	1,562,014	1,23
	32,823,900	43,035,030	7,541,960	7,811,663	40,365,860	50,846,693	....
Av. value per ton...	....	1.31	....	1.04	....	1.26	...
1921.							
Granite	2,771,070	4,032,200	325,340	414,887	3,096,410	4,447,087	1.44
Basalt and related rocks (trap rock)	7,358,230	9,740,418	927,450	1,172,655	8,285,680	10,913,073	1.32
Limestone	23,985,790	27,903,303	4,734,620	4,329,135	28,720,410	32,232,438	1.12
Sandstone	1,190,410	1,808,083	349,060	406,987	1,539,470	2,215,070	1.44
Miscellaneous	1,460,290	1,854,980	100,580	54,830	1,560,870	1,909,810	1.22
	36,765,790	45,338,984	6,437,050	6,378,494	43,202,840	51,717,478	....
Av. value per ton...	....	1.23	....	0.99	....	1.20	....

Portland Cement

Portland cement produced in the United States, 1920 *and* 1921, *by States.*

	Active plants.		Production. Barrels.		Average factory price per barrel.	
	1920	1921	1921	1920	1921	1920
Alabama	3	3	1,131,560	1,743,287	$2.29	$2.02
California	9	9	7,098,084	7,302,784	2.19	2.35
Illinois	4	4	5,538,558	5,587,825	1.94	1.74
Iowa	4	4	4,849,228	4,590,920	1.98	1.79
Kansas	7	7	4,340,794	3,781,494	2.08	1.99
Michigan	11	11	4,891,457	5,777,533	2.46	1.81
Missouri	5	5	6,017,517	4,446,091	1.96	1.84
New Jersey	2	2	2,711,169	2,803,774	1.99	1.70
New York	9	8	5,885,058	5,294,188	2.02	1.88
Ohio	5	5	1,780,433	2,563,773	2.13	1.83
Oklahoma	3	2	1,553,652	1,631,525	2.21	2.14
Pennsylvania	21	22	28,269,314	27,628,598	1.90	1.76
Texas	5	5	2,562,208	2,668,741	2.25	2.35
Washington	4	4	1,798,593	1,678,863	2.27	2.53
Other States (a)	25	24	21,595,260	21,342,653	1.97	1.88
	117	115	100,023,245	98,842,049	2.02	1.89

(a)—Colorado, Georgia, Indiana, Kentucky, Maryland, Minnesota, Montana, Nebraska, Oregon, Tennessee, Utah, Virginia, and West Virginia.

Portland Cement burned by different fuels in 1920 *and* 1921.

Fuel.	Number of plants.	Number of kilns.	Barrels of Cement.	Percentage of total.
Coal	92	607	80,557,675	81.5
Coal and crude oil	3	31	5,536,128	5.6
Coal and gas	1	6	5,536,128	5.6
Crude oil	16	81	10,123,781	10.2
Crude oil, coal, and gas	2	9	2,624,465	2.7
Natural gas	1	6	2,624,465	2.7
	115	740	98,842,049	100.0

Production, shipments, and stocks of finished Portland Cement in 1921 *and* 1922.

Month.	Production (barrels) 1921	1922	Shipments (barrels) 1921	1922	Stocks at end of month (barrels) 1921	1922
January	4,098,000	a4,291,000	2,539,000	a2,931,000	10,300.000	a13,316,000
February	4,379,000	4,278,000	3,331,000	3,285,000	11,400,000	a14,142,000
March	6,763,000	6,685,000	6,221,000	7,002,000	12,000,000	a13,848,000
April	8,651,000	9,243,000	7,919,000	8,592,000	12,600,000	a14,470,000
May	9,281,000	11,176,000	9,488,000	12,749,000	12,450,000	a12,893,000
June	9,296,000	11,245,000	10,577,000	13,470,000	11,150,000	a10,718,000
July	9,568,000	11,557,000	10,301,000	13,850,000	10,414,000	a 8,433,000
August	10,244,000	11,664,000	12,340,000	14,361,000	8,280,000	a 5,746,000
September	10,027,000	11,424,000	11,329,000	12,444,000	6,953,000	a 4,724,000
October	10,506,000	12,287,000	12,114,000	12,854,000	5,348,000	a 4,149,000
November	8,921,000	11,349,000	5,195,000	10,167,000	9,091,000	a 5,320,000
December	6,559,000	8,671,000	3,697,000	4,858,000	11,938,000	9,134,000
	98,293,000	113,870,000	95,051,000	116,563,,000	....	....

Principal hydraulic cements produced in the United States, 1917-1921.

Year.	Natural and puzzolan cements. Barrels.	Value.	Portland cement. Barrels.	Value.	Total. Barrels.	Value.
1917	639,456	$435,370	92,814,202	$125,670,430	93,453,658	$126,105,800
1918	432,966	401,341	71,081,663	113,730,661	71,514,629	114,132,002
1919	528,589	583,554	80,777,935	138,130,269	81,306,524	138,713,823
1920	767,481	1,150,890	100,023,245	202,046,955	100,790,726	203,197,845
1921	769,997	992,623	98,293,000	183,807,910	99,062,997	184,800,533

Portland Cement produced and shipped in the United States in 1921, by districts.

Commercial district.	Production Barrels.	Shipments. Barrels.	Value.	Average factory price.
Lehigh district (eastern Pennsylvania and western New Jersey)	23,648,000	22,933,000	$39,674,090	$1.73
New York	5,295,000	5,040,000	9,576	1.90
Ohio and western Pennsylvania	9,055,000	8,819,000	15,256,870	1.73
Michigan and northeastern Indiana	6,189,000	6,099,000	11,039,190	1.81
Illinois and remainder of Indiana	14,939,000	14,413,000	24,213,840	1.68
Maryland, Kentucky, Virginia, and West Virginia	4,604,000	4,482,000	8,202,060	1.83
Alabama, Tennessee, and Georgia	4,220,000	4,097,000	7,948,180	1.94
Iowa, Minnesota, and Missouri	10,519,000	9,959,000	17,627,430	1.77
Kansas, Nebraska, Oklahoma, and Texas	8,438,000	8,018,000	17,799,960	2.22
Colorado and Utah	1,865,000	1,826,000	4,254,580	2.33
California	7,073,000	6,934,000	16,294,900	2.35
Washington, Montana, and Oregon	2,448,000	2,431,000	6,101,810	2.51
	98,293,000	95,051,000	177,988,910	1.87
Total, 1920	100,023,245	96,311,719	194,439,025	2.02
Percentage of change in 1921	—1.7	—1.3	—8.5	—7.4

Production of finished Portland Cement by months for 1922.

Month.	Production.
January	a4,291,000
February	4,278,000
March	6,685,000
April	9,243,000
May	11,176,000
June	11,245,000
July	11,557,000
August	11,664,000
September	11,424,000
October	12,287,000
November	11,349,000
December	8,671,000
	113,870,000

Sulphur.

The quantity of sulphur produced in 1920—1,255,249 long tons—was the largest produced in any year except 1918, when the output reached 1,353,525 long tons, according to the United States Geological Survey, Department of the Interior. The shipments in 1920, amounting to 1,517,625 long tons, exceeded those of any other year. Two mines in Texas and one in Louisiana and Nevada furnished all the sulphur produced in this country in 1920. The value of the shipments in 1920 is estimated at $30,000,000. The sulphur produced in 1921 amounted to 1,879,150 long tons, which is about one-third more than was produced in 1920. On the other hand the shipments in 1921 were nearly one-third less than in 1920, amounting to only 954,344 long tons, as against 1,517,625 long tons. It is therefore evident that large stocks of sulphur are now on hand. Two mines in Texas and one each in Colorado, Louisiana, Nevada and Utah contributed to the output in 1921. In 1920 and 1921, as in former years, more than 99½ per cent of the sulphur produced in this country came from mines in Texas and Louisiana.

The exports of sulphur in 1920 amounted to 477,450 long tons, valued at $8,994,350 and in 1921 to 285,762 long tons, valued at $4,524,788, according to records of the Bureau of Foreign and Domestic Commerce of the Department of Commerce. It is therefore apparent that the exports of sulphur decreased about two-fifths in 1921 and that there was a drop in value of $3 a ton from 1920 to 1921. The imports of sulphur dropped from 136 long tons in 1920 to 50 long tons in 1921, and the value decreased about $7.50 per long ton.

Potash.

Potash produced in the United States in 1920 and 1921, by States.

State.	Number of plants.	crude potash (short tons).	Available content of potash (K_2O). Short tons.
1920.			
Nebraska	12	87,100	21,804
California[1]	11	30,868	12,234
Utah[2]	6	34,905	10,069
Colorado	3	4,095	1,683
Wisconsin	10	345	207
Pennsylvania	10	2,256	176
Michigan	7	93	56
Other States[3]	7	7,172	1,848
	66	166,834	48,077
1921.			
California	6	13,075	6,187
Pennsylvania	5	1,257	106
Other States[3]	9	11,153	3,878
	20	25,485	10,171

Road Material Specifications

Requirements of the U. S. Bureau of Public Roads on road building materials

ONE-COURSE PORTLAND CEMENT CONCRETE PAVEMENT.

Fine Aggregate: Fine aggregate shall consist of sand composed of clean, hard, durable, uncoated grains, free from lumps, soft or flaky particles, organic matter, loam or other deleterious substances. Sand for reinforced concrete shall be free from salt and alkali.

Grading: Fine aggregate shall be well graded from coarse to fine and, when tested by means of laboratory screens and sieves, shall meet the following requirements:

	Per cent
Passing ¼ inch screen	100
Retained on Standard No. 10 sieve	5-25
Passing a Standard No. 50 sieve	5-25
Passing a Standard No. 100 sieve, not more than	.10
Weight removed by elutriation test, not more than	3

Coarse Aggregate: The coarse aggregate shall consist of fragments of broken stone, slag or gravel conforming to the following requirements:

(a) **Broken Stone:** Broken stone shall be obtained from clean, tough, durable rock, and shall be free from soft, thin, elongated or laminated pieces, disintegrated stone, vegetable or other deleterious substances.

The stone shall have a per cent of wear of not more than five (5).

(b) **Slag:** Broken slag shall consist of clean, tough, durable pieces of iron furnace slag, reasonably uniform in density and quality, nonglassy and free from thin or elongated pieces. It shall be air-cooled and shall have been exposed to the weather for a period of at least six months prior to use. The dried slag shall have a weight per cubic foot of not less than seventy-five (75) pounds when tested according to A. S. T. M. Standards, 1921, Serial Designation C 20-21.

(c) **Gravel:** Gravel shall consist of clean, hard durable and uncoated pebbles of high resistance to abrasion. Gravel for reinforced concrete shall be free from salt and alkali.

Grading: Coarse aggregate shall be graded uniformly from the maximum size to pieces one-quarter (¼) inch in diameter, and, when tested by means of laboratory screens, shall meet the following requirements:

	Per cent
Passing 2 inch screen	100
Total passing 1 inch screen	40-75
Passing ¼ inch screen, not more than	10
Passing ⅛ inch square opening, not more than	5

GRAVEL SURFACE.

Material: The gravel shall be composed of fragments of hard, durable rock, of high resistance to abrasion, together with sand and clay or other binding material and shall be free from thin or elongated pieces.

The cementing value of material passing the one-quarter inch screen shall be not less than 50.

When tested by means of laboratory screens, the gravel shall meet the following requirements:

	Per cent
Passing a 2 inch screen, not less than	95
Total passing a ¼ inch screen	50 to 25
The material retained on the ½ inch screen, when tested by means of a laboratory screen, shall meet the following requirement:	
Total passing a 1 inch screen	25 to 75
The material passing the ¼ inch screen, when tested by means of a laboratory sieve, shall meet the following requirement:	
Total passing a Standard No. 200-mesh sieve	15 to 35

WATER BOUND MACADAM SURFACE COURSE.

Coarse Stone: The broken stone shall consist of angular fragments of rock (excluding schist, shale and slate) of uniform quality throughout, free from thin or elongated pieces, soft or disintegrated stone, dirt, or other objectionable matter. The stone shall have a per cent of wear of not more than six (6).

This material shall be uniformly graded, and shall consist of that portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

	Per cent
Passing 2½ inch screen, not less than	95
Passing 1¼ inch screen, not more than	15

Coarse Slag: The broken slag shall consist of angular fragments

reasonably uniform in density and quality, free from metallic iron or copper, thin or elongated pieces, dirt or other objectionable matter.

It shall meet the following requirements:

Weight per cubic foot, compacted by shaking to refusal, each size specified, not less than................70 lbs.
Per cent of wear, not less than...... 8
This material shall be graded as specified for "Coarse Stone."

Screenings: The screenings shall consist of material similar to that specified for "Coarse Stone" or "Coarse Slag" and shall be that portion of the product of the crusher including the dust of fracture which, when tested by means of laboratory screens will meet the following requirements:

	Per cent
Passing ¾ inch screen, not less than.	95
Total passing ¼ inch screen.......	40 to 80

SINGLE SURFACE TREATMENT.

Stone Chips: The broken stone chips shall consist of angular fragments of clean, hard, tough durable rock of uniform quality throughout, free from soft or disintegrated stone, dirt, or other objectionable matter. It shall be that product of the crusher, which when tested by means of laboratory screens, will meet the following requirements.

	Per cent
Passing ¾ inch screen, not less than..	95
Passing ¼ inch screen, not more than	15

Gravel: The gravel shall consist of clean, hard, tough, durable stone, free from soft or disintegrated particles, dirt or other objectionable matter. When tested by means of laboratory screens it shall meet the following requirements:

	Per cent
Passing ½ inch screen, not less than.	85
Passing ¼ inch screen, not more than	15

BITUMINOUS MACADAM SURFACE COURSE.

Broken Stone: The broken stone shall consist of angular fragments of rock, excluding schist, shale and slate, of uniform quality throughout, free from thin or elongated pieces, soft and disintegrated stone, dirt, or other matter occurring either free or as a coating on the stone. The stone shall meet the following requirements:

	Per cent
Per cent of wear not less than five and one-half (5.5)	
Passing 3½ inch screen, not less than	95
Passing 1¼ inch screen, not more than	15

It shall be uniformly graded and shall consist of that portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

	Per cent
Passing 2½ inch screen, not less than..	95
Passing 1¼ inch screen, not more than	15

Stone Chips: The chips for filling the surface voids in the coarse stone and to be used on the seal coat shall conform to the requirements for "Coarse Stone" above, except that they shall consist of that portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

	Per cent
Passing ¾ inch screen, not less than..	95
Passing ¼ inch screen, not more than	15

BITUMINOUS CONCRETE.
(Coarse-Aggregate Type.)

Coarse Aggregate The coarse aggregate shall consist of angular fragments of rock, excluding schist, shale and slate, free from thin, elongated pieces, soft or disintegrated stone, dirt, or other objectionable matter occurring either free or as a coating on the stone. It may be the entire product of the crushing of stone having a per cent of wear of not more than five (5), and a toughness of not less than eight (8), and shall meet the following requirements:

	Per cent
Passing a 1¼ inch screen.........	100
Total passing a ¾ inch screen....	45 to 75
Passing a ¼ inch screen...........	25

Fine Aggregate: The fine aggregate shall consist of sand, or a combination of sand and screenings. Sand shall be composed of sound, durable stone particles free from a coating of clay or loan. Screenings shall be of the same or similar material as specified for "Coarse Aggregate." The sand or the combination of sand and screenings shall meet the following requirements:

	Per cent
Passing a Standard No. 10 sieve, not less than	95
Total retained on a Standard No. 40 sieve.	12 to 40
Passing a Standard No. 40 sieve, retained on a Standard No. 80 sieve.	25 to 60
Passing a Standard No. 80 sieve, retained on a Standard No. 200 sieve.	20 to 45
Passing a Standard No. 200 sieve, not over	6

BITUMINOUS CONCRETE
(Modified Topeka or Stone-Filled Sheet Asphalt.)

Coarse Aggregate: The coarse aggregate shall consist of angular fragments of rock, excluding schist, shales and slate, free from thin or elongated pieces, soft or disintegrated stone, dirt or other objectionable matter occurring either free or as a coating on the stone. It shall be the product of the crushing of stone having a per cent of wear of not more than five (5), and a toughness of not less than eight (8), and which, when tested by means of laboratory screens, will meet the following requirements:

	Per cent
Passing ½ inch screen, not less than.	95
Passing ¼ inch screen, not more than	80

Fine Aggregate: The fine aggregate shall consist of sand or a combination of sand and screenings. Sand shall be composed of sound, durable stone particules free from a coating of clay or loam. Screenings shall be of the same or similar material as specified for coarse aggregate. The sand or combination of sand and screenings shall meet the following requirements:

	Per cent
Passing a Standard No. 10 sieve, not less than	95
Total retained on a Standard No. 40 sieve	12 to 40
Passing a Standard No. 40 sieve, retained on a Standard No. 80 sieve	25 to 60
Passing a Standard No. 80 sieve, retained on a Standard No. 200 sieve	25 to 45
Passing a Standard No. 200 sieve, not over	6

SHEET ASPHALT PAVEMENT.

Broken Stone for Binder Course: The broken stone for binder course shall consist of angular fragments of rock, excluding schist, shale and slate, free from thin or elongated pieces, soft or disintegrated stone, dirt or other objectionable matter, occurring either free or as a coating on the stone, having a toughness of not less than eight (8), and shall meet the following requirements:

	Per cent
Passing 1 inch screen, not less than..	95
Passing ¾ inch screen, not more than	25

Sand for Binder Course: Sand for binder course shall consist of hard durable grains. It shall be clean and shall meet the following requirements:

	Per cent
Passing ¼ inch screen, not less than	100
Passing Standard No. 200 sieve, not more than	6

Weight, etc., of various minerals

Materials	Sp. Gr.	Weight Lbs. per cu. ft.	Weight Lbs. per cu. ft.	Angles of repose.
Cinders, bituminous	....	45	....	45
Clay, dry	1.52	95	....	36.53
Earth, loose, dry	1.36	85	2295	15.57
Feldspar	2.70	168.5	....	.....
Flint	2.59	162	....	.....
Granite (av.)	2.68	167.5	4523	.....
Graphite	2.26	141	....	.....
Gravel, dry	1.79	112	3024	36.53
Gravel, wet	2	125	3375	.....
Greenstone	2.96	185	....	.....
Grindstone	2.14	134	....	.....
Gunpowder	1	62.4	....	.....
Gypsum, calcined, lump	1.80	112	....	.....
Gypsum, powder, loose	.97	60	....	.....
Gypsum, powder, solid	2.55	159	....	.....
Gypsum, unburned	2.30	144	....	.....
Kaolin	2.2	137	....	.....
Lime, freshly burned	.96	60	1620	.....
Limestone (av.)	2.6	162.5	4388	.....
Magnesite	3	172	....	.....
Marble	2.77	173	....	.....
Marl	2.1	131	....	.....
Potash	2.05	128	....	.....
Sand, coarse	1.52	95	2565	.....
Sand, fine, dry	1.60	100	2700	.....
Sand, fine, wet	1.98	124	3348	.....
Sand, mixed, dry	1.85	115	3105	33.41
Sandstone (av.)	2.47	154	4158	.....
Shale	2.6	162	....	.....
Silica	2.66	166	....	.....
Slag	....	40	....	.....
Soapstone	2.73	170	....	.....
Stone, crushed	..	...	..	45
Talc	2.73	170	....	.....
Trap Rock	2.96	185	4995	.....

Table Showing the Number of Cubic Yards of Rock Displaced Per Foot of Bore Hole at Different Spacings

Distance of Bore Holes Back from Face	Distance Between Bore Holes															
	5 Ft.	6 Ft.	7 Ft.	8 Ft.	9 Ft.	10 Ft.	11 Ft.	12 Ft.	13 Ft.	14 Ft.	15 Ft.	16 Ft.	17 Ft.	18 Ft.	19 Ft.	20 Ft.
5	.92	1.11	1.3	1.49	1.66	1.85	2.04	2.22	....	.....	.....	.....	.....	.....	.....	.....
6	1.11	1.33	1.55	1.77	2.0	2.22	2.44	2.65	....	.....	.....	.....	.....	.....	.....	.....
7	1.3	1.55	1.81	2.0	2.33	2.7	2.85	3.11	....	.....	.....	.....	.....	.....	.....	.....
8	1.49	1.77	2.0	2.37	2.65	2.96	3.26	3.55	....	.....	.....	.....	.....	.....	.....	.....
9	1.66	2.0	2.33	2.65	3.0	3.33	3.66	4.0	....	.....	.....	.....	.....	.....	.....	.....
10	1.85	2.22	2.7	2.96	3.33	3.7	4.1	4.44	4.81	5.18	5.55	5.92	.....	.....	.....	.....
11	....	....	....	3.26	3.66	4.1	4.48	4.88	5.3	5.7	6.11	6.52	.....	.....	.....	.....
12	....	....	....	....	4.0	4.44	4.88	5.33	5.77	6.22	6.66	7.11	.....	.....	.....	.....
13	....	....	....	....	....	4.81	5.3	5.77	6.26	6.22	7.22	7.70	.....	.....	.....	.....
14	....	....	....	....	....	4.81	5.3	5.77	6.26	6.74	7.77	8.30	.....	.....	.....	.....
15	....	....	....	....	....	5.55.	.6.11	6.66	7.22	7.77	8.33	8.88	9.44	10.0	10.55	11.11
16	....	....	....	....	....	....	....	7.11	7.70	8.30	8.88	9.48	10.07	10.66	11.3	11.85
17	....	....	....	....	....	....	....	7.55	8.18	8.81	9.44	10.07	10.70	11.33	11.96	12.59
18	....	....	....	....	....	....	....	8.0	8.66	9.33	10.0	10.66	11.33	12.0	12.66	13.33
19	....	....	....	....	....	....	....	....	9.15	9.85	10.55	11.3	11.96	12.66	13.37	14.07
20	....	....	....	....	....	....	....	....	9.63	10.37	11.11	11.85	12.59	13.33	14.07	14.81
21	....	....	....	....	....	....	....	....	....	.....	11.66	12.44	13.22	14.37	14.77	15.55
22	....	....	....	....	....	....	....	....	....	.....	12.22	13.03	13.85	14.66	15.48	16.30
23	....	....	....	....	....	....	....	....	....	.....	12.78	13.63	14.48	15.33	16.18	17.03
24	....	....	....	....	....	....	....	....	....	.....	13.33	14.22	15.11	16.0	16.88	17.77
25	....	....	....	....	....	....	....	....	....	.....	13.88	14.81	15.74	16.66	17.60	18.51
26	....	....	....	....	....	....	....	....	....	.....	14.44	15.74	16.37	17.33	18.30	19.26
27	....	....	....	....	....	....	....	....	....	.....	15.0	16.15	17.0	18.0	19.0	20.0
28	....	....	....	....	....	....	....	....	....	.....	15.55	16.6	17.63	18.52	19.7	20.74
29	....	....	....	....	....	....	....	....	....	.....	16.1	17.18	18.26	19.33	20.4	21.48
30	....	....	....	....	....	....	....	....	....	.....	16.66	17.77	18.88	20.0	21.1	22.22

Note: To reduce to tons: For limestone multiply by 2.27; for traps, syenites multiply by 2.52; for granites multiply by 2.3; for shale multiply by 2.18; for glass, sand or gravel multiply by 1.55.

Glossary of Terms

Abandonment. Abandonment of a mining claim may be by failure to perform work; by conveyance; by absence, and by lapse of time. The abandonment of a mining claim is a question of intent. To constitute an abandonment of a mining claim, there must be a going away, and a relinquishment of rights, with the intention never to return, and with a voluntary and independent purpose to surrender the location or claim to the next comer.

Abbe tube mill. A gear-driven tube mill supported on a pair of riding rings and distinguished by an archimedes spiral, through which the ore is fed and discharged. Grinding is effected by flint pebbles fed into mill.

Ablation. 1. The formation of residual deposits by the washing away of loose or soluble minerals. 2. The wearing away of rocks, or the surface melting of glaciers.

Abrade. To rub or wear off; to waste or wear away by friction, as to abrade rocks.

Abrasion. The act or process of rubbing or wearing away; as the abrasion of rock or earth by glaciers.

Abrasive. A substance used for abrading, as for grinding and polishing. The principal substances used as abrasives are: Burstone, corundum, emery, garnet, grindstone, infusorial earth, millstone, novaculite, oilstone, pumice, scythstone, tripoli, volcanic ash, and whetstone. Certain furnace products, as carborundum, etc., are also used as abrasives.

Absarokite. A general name given by Iddings to a group of igneous rocks in the Absaroka Range, in the eastern portion of the Yellowstone Park. They have porphyritic texture with phenocrysts of olivine and augite in a groundmass, that is either glassy or contains leucite, orthoclase or plagioclase, one or several.

Absorb. To drink in, to sukc up, as a liquid by a solid like a sponge or fuller's earth.

Absorbing well. An excavation in the earth through which surface water finds its way to a permeable stratum and is drained away.

Abstraction. In geology, the withdrawal of a stream from a lower portion of its course by an adjoining stream having more rapid corrosive action.

Abyssal rocks. Plutonic, or deep-seated igneous rocks.

Acadialite. A reddish variety of chabazite.

Accessory minerals. Those mineral constituents of a rock that occur in such small amounts that they are disregarded in its classification and definition.

Accretion. The process by which inorganic bodies grow larger, by the addition of fresh particles to the outside.

Acidic. A descriptive term applied to those igneous rocks that contain more than 65 per cent SiO_2 as contrasted with intermediate and basic.

Acid rock. A term rather loosely used in lithology, generally to mean one of the following: 1. An igneous rock containing 60 per cent or more of silica, free or combined, in this sense being nearly equivalent to acidic. 2. An igneous rock in which minerals high in silica, such as quartz, alkaline feldspar, and muscovite, are dominant. 3. Very loosely, an igneous rock composed dominantly of light-colored minerals. In all three senses contrasted with basic.

Acinose. Granulated like seeds; applied to mineral texture.

Aclinic. Having no inclination or dip; situated where the compass needle does not dip, as the aclinic line, or magnetic equator.

Acreage rent. Royalty or rent paid by the lessee for working and disposing of minerals at the rate of so much per acre.

Acre-foot. The amount of water required to cover 1 acre to a depth of 1 foot; equal to 43,560 cubic feet.

Acrotomous. In mineralogy, having a cleavage parallel with the base or top.

Actinolite. A light-green calcium-magnessium-iron amphibole. 3Mg(Fe)O. CaO. $4SiO_2$.

Actual horsepower. The horsepower really developed, as proved by trial.

Adamant. A stone imagined by some to be of impenetrable hardness; a name given to the diamond and other substances of extreme hardness; in modern mineralogy it has no technical signficance .

Adamantine. 1. Like a diamond in hardness or luster. 2. Made of, or having the qualities of adamant. 3. Crystallized boron. 4. A commercial term for chilled steel shot used in well drilling.

Adamantine drill; Shot drill. A core drill employed in rotary drilling in very hard ground. A steel-cylinder bit with a diagonal slot cut in the lower edge is attached to a core barrel and a small quantity of chilled steel shot fed in with the water at intervals. These find their way beneath the bit and wear away the rock as the bit rotates. A core from 4 to 30 inches in diameter is obtained.

Adamantine spar. A variety of corundum.

Adhesive slate. A very absorbent slate that adheres to the tongue if touched by it.

Adait. 1. A nearly horizontal passage from the surface by which a mine is entered. In the United States an adit is usually called a tunnel, though the latter, strictly speaking, passes entirely through a hill and is open at both ends. Frequently also called Drift, or Adit level.

2. As used in the Colorado statutes it may apply to a cut either open or under cover, or open in part and under cover in part, dependent on the nature of the ground.

Adular; aldularia. A pure or nearly pure potassium-aluminum silicate; a variety of orthoclase. $KAlSi_3O_8$.

Advance workings. Mine workings that are being advanced into the solid, and from which no pillars are being removed.

Advanced gallery. A small heading driven in advance of the main tunnel in tunnel excavation.

Advertised out. A term used to express the result of the action of a joint owner of a claim who by proper notices causes the interest of his co-owner to be forfeited for failure to perform his share of the assessment work.

Aegirite. (Also written Aegerine.) The name of this soda-pyroxene is often prefixed to normal rock names because of its presence, as for instance, aegirit-granite, aegir-

ite-trachyte.

Aeolian. An adjective applied to rocks formed of wind-borne sands. Some such aeolian sands yield large quanities of oil; practically all the big Baku spouters have been obtained from sands of this class.

Aeolian rocks. Fragmental rocks, composed of wind-drifted materials. The drift-sand rock, the common building stone of Bermuda, is a good example.

Aerate. 1. To expose to the action of the air; supply or charge with air. 2 To charge with carbon dioxide or other gas, as soda water. (Standard)

Aerator. 1. An apparatus for charging water with gas under pressure, especially with carbon dioxide. 2. Any contrivance for supplying a stream of air or gas, as for fumigating, destroying fungi, insects, etc. (Standard)

Aerial. Relating to the air or atmosphere. "Subaerial" is applied to phenomena occurring under the atmosphere; "subaqueous" to phenomena occurring under water. (Power)

Aerial railroad. A system of cables from which to suspend cars or buckets, as in transporting or hoisting.

Aerial spud. A cable for moving and anchoring a dredge.

Aerial tramway. A system for the transportation of material, as ore or rock, in buckets suspended from pulleys or grooved wheels that run on a cable, usually stationary. A moving or traction rope is attached to the buckets and may be operated by either gravity or other power, as determined by topographic features or other conditions.

Aerolite. A mass of metallic or other mineral substance which has fallen to the earth through the air. The metallic aerolite consists principally of metallic iron, nickel, and chromium; the nonmetallic aerolite consists of crystalline rocks resembling greenstones; others consist of mixtures of these. A meteorite.

Aerophore. 1. A respirator in the form of a tank which receives the exhalations from the lungs and containing chemicals designed to revive the air, to render it fit for breathing.

2. A portable apparatus containing a supply of compressed air for respiration, as for a miner.

Afilar (Mex.). To sharpen (tools).

Afterdamp; Aftergases. The mixture of gases which remain in a mine after a mine fire or an explosion of fire damp. It consists of carbonic acid gas, water vapor (quickly condensed), nitrogen, oxygen, carbon monoxide, and in some cases free hydrogen, but usually consists principally of carbonic acid gas and nitrogen, and is therefore irrespirable.

Against the air. In a direction opposite to that in which the air current moves. To fire shots "against the air," is to fire shots in such an order that the shot firer travels against the air.

Agalite. Fibrous talc, pseudomorphous after enstatite.

Agalmatolite. Essentially a hydrous silicate of aluminum and potassium, corresponding closely to muscovite. A secondary or alteration product. See also Pinite. A soft waxy mineral used for carvings by the Chinese. Also called Lardstone.

Agglomerate. 1. A breccia composed largely or wholly of fragments of volcanic rocks. More specifically, a heterogeneous mixture of fragments of volcanic and other rocks filling the funnel or throat of an extinct or quiescent volcano.

Aggradation. 1. In geology, the natural filling up of the bed of a watercourse by deposition of sediment. 2. Specifically, the building up by streams in arid regions of fan-like graded plains, by reason of the shifting streams and the loss of the water in the dry soil.

Aggregate. The mineral material, such as sand, gravel, shells, slag, or broken stone, or combinations thereof, with which cement or bituminous material is mixed to form a mortar or concrete.

Agricolite. An adamantine colorless or yellow bismuth silicate.

Ahonde. (Mex.). A shaft to establish mining title. A discovery shaft.

Ailsyte. A name derived from Ailsa Craig, Scotland, and suggested for a microgranite containing considerable riebeckite.

Ainalite. A variety of cassiterite containing tantalum pentoxide.

Air adit. An adit driven for the purpose of ventilating a mine.

Air blast. A disturbance in mines accompanied by a strong rush of air through the workings. It is caused by the falling of large masses of roof in stopes, or by sudden crumbling of pillars under the weight of the rock above the mine workings, due to a stress on the rocks, which has produced a strain, and in mining operations this strain results in a violent rupture. Such a disturbance is sometimes called "quake," and the rock "explosive rock."

Air compressor. A machine for compressing air to a pressure sufficient to actuate machinery.

Air condenser. A surface condenser cooled by contact with air instead of water.

Air drill. A rock drill driven by compressed air, as distinguished from a drill driven by steam.

Air hammer. A pneumatic hammer.

Air hoist. Hoisting machinery operated by compressed air.

Air hole. A hole drilled in advance to improve ventilation by communication with other workings or with the surface.

Air receiver. A strong vessel, into which air from a compressor is delivered. It serves as a reservoir to equalize the pressure before the air is used. It also cools the air collects moisture, which may be drawn off, and eliminates the pulsating effect of the piston strokes.

Air-reduction process. See Roasting and reaction process.

Air shaft. A shaft used for ventilating mines; it may either receive or discharge the circulating current.

Air shot. A shot prepared by loading (charging) in such a way an air space is purposely left in contact with the explosive for the purpose of lessening its shattering effect.

Air shrinkage. The decrease in volume which a clay undergoes in drying.

Air-slaked. Slaked by exposure to the air; as air-slaked lime.

Air trunk. A large pipe or shaft for conducting air, as for ventilation, or to a furnace.

Air tub. The cylinder on a blowing engine that pumps the blast of wind or air.

Air vessel. A chamber connected with a pump and partly filled with air to regulate the flow of water and lessen shocks.

Akerite. A variety of syenite, consisting of orthoclase, considerable plagioclase, biotite, augite, and some quartz.

Akins' classifier. A classifier consisting of an interrupted-flight screw conveyor, operating in an inclined trough.

Alabandite. Manganblende. Manganese sulphide, MnS.

Alabaster. Compact fine-graned gypsum, white or delicately shaded.

Alaskite. Any igneous rock consisting essentially of quartz and alkalic feldspar, without regard to texture.

Albite. An end member of the plagioclase series of feldspars, containing no calcium and consisting of sodium-aluminum silicate; sodium feldspar.

Albitrophyre. A dike rock containing large polysynthetic phenocrysts of albite. In the groundmass are microlites of the same mineral, together with chlorite and limonite.

Albolite; Albolith. A kind of plastic cement or artificial stone, consisting chiefly of magnesia and silica.

Alboranite. A variety of hypersthene-andesite, poor in soda, from the island of Alboran, east of the Straits of Gibraltar.

Alexanderite. An emerald-green variety of chrysoberyl, columbine-red by transmitted light.

Algonkian; Proterozoic. In the nomenclature of the United States Geological Survey, the second in order of age of the systems into which the stratified rocks of the earth's crust are divided; also the corresponding period of geologic time. Some authorities use Proterozoic in the same sense.

Alkali. In chemistry, any substance having marked basic properties. In its restricted and common sense the term is applied only to hydroxides of potassium, sodium, lithium, and ammonium. They are soluble in water, have the power of neutralizing acids and forming salts with them, the property of corroding organic substances, and of turning red litmus blue. In a more general sense the term is applied to the hydroxides of the so-called alkaline-earth metals; barium, strontium and calcium.

Alkaline. 1. Applied to minerals having the taste of soda. 2. Of or pertaining to the properties of an alkali.

Allagite. A heavy dull red or green altered carbonated rhodonite.

Allanite; Orthite. 1. A complex variable silicate of aluminum, iron the cerium metals, and, in smaller quantity, those of the yttrium group. 2. A comparatively rare mineral related to common epidote and occurring generally as a microscopic constituent of igneous rocks. It contains a number of the rarer elements.

Alley stone. A synonym for Websterite. Aluminite.

Alliaceous. Applied to minerals having the odor of garlic, for example, arsenical minerals. (Dana)

Alligator. 1. See Squeezer. 2. A rock breaker operating by jaws.

Allomorph. In mineralogy, a pseudomorph formed without change of chemical composition, as calcite after arangonite.

Allophane. A hydrous silicate of luminum, amorphous, translucent, and of various colors, often in incrustations or stalactitic forms.

Alluvium. The deposit of loose gravel, sand and mud that usually intervenes in every district between the supeficial covering of vegetal mould and the subjacent rock. It is generally used today for the earthy deposit made by running streams, especially during times of flood.

Almond rock. An amygdaloid.

Alnoite. A very rare rock with the composition of a melilite basalt.

Aloes rope. A special kind of rope, sometimes used in oil-well drilling, the breaking strain of which is 300 kg. per circular centimeter. It is manufactured from the aloe, a plant indigenous to Cape Colony.

Alum earth. An argillaceous rock, containing considerable pyrite, and largely impregnated with bitumen.

Alumina. Oxide of aluminum, Al_2O_3. Pure crystalline alumina is represented by corundum, sapphire, and ruby. The commonest form of alumina is as a silicate, of which clays are mostly composed, and as the compound silicates of aluminum and other metals, of which a large class of minerals is formed.

Aluminite. A hydrous sulphate of aluminum. $Al_2O_3SO_39H_2O$, usually occurring in white reniform masses.

Alumocalcite. A variety of opal with alumina and lime as impurities.

Alum schist, shale, or slate. A clayey rock containing carbonaceous material and marcasite that when decomposed yields by efflorescence common alum.

Alum shale. Shale charged with alum, that in favorable localities may be commercially leached out and crystallized.

Alum stone. An impure siliceous alunite.

Alunite; Alumstone. A hydrous sulphate of aluminum and potassium, $K(AlO)_3(SO_4)_2$ $3H_2O$, containing 11.4 per cent potash, K_2O. Closely resembles kaolinite and occurs in similar locations. Generally the result of the action of water, containing sulphuric acid, on feldspathic rocks, as when pyrite in granite porphyry is oxidized.

Alunogen. A hydrous aluminum sulphate $Al_2(SO_2)_3+18H_2O$, frequently found on the walls of mines and quarries. Also called Feather alum and Hair salt.

Ammonia gelatin. An explosive consisting of blasting gelatin, ammonium nitrate, and charcoal.

Ammonite. Ammonium nitrate explosives, containing from 70 to 95 per cent mmonium nitrate, besides combutile components, which are so-callel carbon carriers, as resin, meal, naphthalene.

Amorphism. The state or quality of being amorphous; especially, the absence of crystalline structure.

Amorphous. Without form; applied to rocks and minerals having no definite crystalline structure.

Amortization. The repayment of a debt, principal and interest, in equal annual installments. Frequently used in finance as the extinction of a debt, regardless of the means employed.

Amortization schedule. In finance, a table so constructed as to show the principal remaining due or outstanding immediately after the annual payment, the interest for the interval, and the amount of principal repaid.

Amperage. The strength of an electric current measured in amperes.

Ampere. The practical unit of electric current; the current produced by 1 volt acting through a resistance of 1 ohm.

Ampere foot. One ampere flowing through 1 foot of an electric conductor. A wire 20 feet long conducting a current of 6 amperes is said to have 120 ampere feet.

Ampere hour. The quantity of electricity delivered in 1 hour by a current whose average strength is 1 ampere.

Ampere meter. An instrument for measuring in amperes the strength of an electric current; an ammeter.

Anaclinal. Descending in a direction opposite to the dip of the strata, as an anaclinal river. Opposed to Cataclinal.

Andesine. A silicate of sodium, calcium, and aluminum, with the sodium in excess of the calcium. An important constituent of adesite and diorite.

Andesite. A volcanic rock of porphyritic or felstitic texture, whose crystallized minerals are plagioclase and one or more of the following: biotite, hornblende, and augite.

Andradite. The common calcium-iron garnet, $Ca_3Fe_2 (SiO_4)_2$. (Dana)

Anegada (Mex.). Drowned; overflowed; left to fill with water. (Dwight)

Anemometer. An instrument for measuring the veocity of air currents.

Angle of incidence. The angle formed by the line of incidence and a line drawn from the point of contact perpendicular to the plane or surface on which the incident ray or body impignes.

Angle of nip. The angle between tangents drawn to an ore particle at the point of its contact with the surface of the rolls.

Angle of pull. The angle between the vertical and an inclined plane bounding the area affected by the subsidence beyond the vertical. Applied to slides of earth.

Angle of rest or repose. The angle with a horizontal plane at which loose material will stand on a horizontal base without sliding. It is often between 30° and 35°.

Angle of slide. The slope, measured in degrees of deviation from the horizontal on which a slide of material will start. It is slightly greater than the angle of rest.

Angus Smith composition. A protective coating for valves, fittings, and pipe used for underground work. It is composed of coal tar, tallow, resin, and quicklime, and must be applied hot.

Anhydrous. Destitute of water, especially water of crystallization.

Annealed wire rope. A wire rope made from wires that have been softened by annealing.

Annealing. The process by which glass and certain metals are heated and then slowly cooled to make them more tenacious and less brittle. Important in connection with the manufacture of steel castings, forgings, etc.

Annular borer. A tool with a tubular bit for removing a cylindrical core as a sample. Used in prospecting.

Annular kiln. A kiln having compartments.

Anode. The positive terminal of an electrical source, or more strictly the electrode by which the current enters an electrolyte on its way to the other pole. Opposed to Cathode.

Anogene. An old name for rocks that have come up from below; i.e., eruptive rocks.

Anorthite. An end-member of the plagioclase feldspar series, the one consisting of calcium-aluminum silicate and containing no sodium.

Anorthoclase. A triclinic feldspar closely related to the orthoclase group. Chiefly a soda-potash feldspar.

Anorthosite. A name applied by T. Sterry Hunt to granitoid rocks that consist of little else than labradorite and that are of great extent in eastern Canada and the Adirondacks.

Antecedent. 1. Pertaining to or characterizing the internal movements of the earth concerned in the elevation of continental masses and their exposure to degradation. Contrasted with consequent. **2.** Established previous to the displacement of a terrane by faulting or folding; as an antecedent valley, antecedent drainage. Contrasted with consequent and superimposed.

Anticline. A fold or arch of rock strata dipping in opposite direction from an axis.

Apatite. A calcium phosphate containing a little flourine or chlorine, $Ca_4(CaF)(PO_4)_3$ or $Ca_4(CaCl)(PO_4)_3$.

Apex. 1. The tip, point, or angular summit of anything, as the apex of a mountain. The end, edge, or crest of a vein nearest the surface. **2.** The highest point of a stratum, as a coal seam. **3.** In geology, the top of an anticlinial fold of strata. This term, as used in United States Revised Statutes, has been the occasion of much litigation. It is supposed to mean something nearly equivalent to outcrop. **4.** The highest point at which the ore or rock is found in place or between the walls of the vein.

Aplite.—A term chiefly applied to finely crystalline muscovite-granite that occurs in dikes.

Apobsidian. Obsidian that has been devitrified by metamorphism.

Apparent superposition. The actual visible order in which strata lie in any locality.

Apron. A hinged extension of a loading chute.

Apyrous. Not changed by extreme heat, as mica: distinguished from Refractory.

Aqueo-igneous. Of, or pertaining to, or resulting from the joint influence of heat and water.

Aqueous rocks. Sedimentary rocks. See also Sedimentary.

Aquifer. A porous rock stratum that carries water.

Aragonite. Orthorhombic calcium carbonate, $CaCO_3$. See also Calcite.

Archeozoic. The era during which, or during the later part of which, the oldest system of rocks was made. (Chamberlin)

Archimedean screw. A spiral screw fitting closely in a tube, for raising water or other liquids; often used as a screw conveyor for sand, gravel, and fine ore.

Archimedes limestone. One of the subordinate beds of the lower Carboniferous series.

Archolithic. Of, or pertaining to the earliest sedimentary rocks, as the Laurenthian and Silurian.

Areal geology. That branch of geology which pertains to the distribution, position, and form of the areas of the earth's surface occupied by different sorts of rock or different geologic formations, and to the making of geologic maps.

Arenaceous. An adjective applied to rocks that have been derived from sand or that contain sand. Not to be confounded with siliceous.

Arenilitic. Of, or pertaining to sandstone.

Arenose. Full of grit or fine sand; gritty.

Argillaceous.—Containing clay, either soft or hardened, as in shale, slate, argillite, etc.; applied to minerals having the odor of moistened clay.

Argillaceous sandstone. A sandstone containing a considerable proportion of clay.

Argillite. 1. A thick-bedded argillaceous sedimentary rock without distinct slaty

cleavage or shaly fracture; mudrock; sometimes called Pelite. 2. A clay slate: in this sense a metamorphic rock with true slaty cleavage.

Argillo-arenaceous. Composed of or containing clay and sand.

Argillo-calareous. Composed of or containing clay and lime.

Argillo-calcite. A clayey calcite.

Argillo-ferruginous. Composed of or containing clay and iron.

Argillo-magnesian. Composed of or containing clay and magnesia or magnesium.

Arkose. 1. A sandstone rich in feldspar fragments, as distinguished from the more common richly quartzose varities. 2. A sedimentary rock composed of material derived from the disintegration of granite, transported and redeposited with little sorting.

Arm. The inclined member or leg of a set or frame of timber.

Armature. 1. A piece of soft iron or steel used to connect the poles of a magnet or of adjacent magnets. 2. That part of a dynamo-electric machine carrying the conductors whose relative movement through the magnetic field between the pole pieces causes an electric current to be induced in the conductors (as in a dynamo); or which by having a current passed through them are caused by electro-magnetic induction to move through this field (as in a motor).

Artificial stone. A stony substance formed from certain basic natural materials which in the course of manufacture undergo chemical changes whereby an entirely new material is created. This new substance is then crushed, graded, molded into desired shapes and baked under intense heat in kilns or ovens. Often used as an abrasive.

Arvonian rock. A rock consisting of quartz-felsites, halleflintas, and breccias, characeteristic of the Cambrian or an earlier period in Wales.

Asbestos. White, gray, or green-gray fibrous variety of amphibole, usually one containing but little aluminum, as tremolite or actinolite; also, improperly, a fibrous serpentine or chrysotile. Called also Earthflax, Mountain-cork, and Amianthus.

Asbolite. An earthy maganese mineral (wad) containing oxide of cobalt, which sometimes amounts to 32 per cent.

Ascension, infiltration by. The theory of infiltration by ascension in solution from below considers that ore-bearing solutions come from the heated zones of the earth, and that they rise through cavities, and at diminished temperatures and pressures deposit their burdens.

Ash-bed diabase. A rock on Keweenaw Point, Lake Superior, resembling a conglomerate, but which is interpreted by Wadsworth as a scoriaceous amygdaloidal sheet into which much sand was washed in its early history.

Asiderite. Daubree's name for stony meteorites that lack metallic iron.

Asmanite. An orthorhombic variety of silica found in meteoric iron.

Asparagus stone. A greenish-yellow variety of apatite.

Asperite. A collective name suggested by G. F. Becker for the rough cellular lavas whose chief feldspar is plagioclase, but of which it is impossible to speak more closely without microscopic determination.

Asperolite. A variety of chrysocolla, containing more than the usual percentage of water. (Chester)

Asphalt. A complex compound of various hydrocarbons, part of which are oxygenated. Related in origin to petroleum. Is brown or brownish black in color, melts at 90 to 100 F., and is mostly or wholly soluble in turpentine.

Asphalt cement. A fluxed or unfluxed asphaltic material, especially prepared as to quality and consistency; suitable for direct use in the manufacture of asphaltic pavements.

Asphatic sandstone. See Sandstone; Asphalt rock.

Asphaltite. A dark-colored, solid, difficultly fusible, naturally occurring hydrocarbon complex, insoluble in water, but more or less completely soluble in carbon disulphide, benzol, etc.

Asphalt rock. Asphalt stone. Limestone impregnated with asphalt. Also a term applied to asphaltic sandstone.

Asphalt stone. See Asphalt rock.

Asphaltum. See Asphalt. 1.

Aspirator. An inhaler.

Assay. 1. To test ores or minerals by chemical or blowpipe examination. To determine the proportion of metals in ores by smelting in the way appropriate to each. Gold and silver require an additional process called cupelling, for the purpose of separating them from the base metals. 2. An examination of a mineral, an ore, or alloy differing from a complete analysis in that it determines only certain ingredients in the substance examined, whereas an analysis determines everything it contains.

Assay foot. The assay value multiplied by the number of feet across which the sample is taken.

Assay ton. A weight of 29.166+grams used in assaying, for convenience. Since it bears the same relation to the milligram that a ton of 2000 pounds does to the troy ounce the weight in milligrams of precious metal obtained from the assay of an ore gives directly the number of ounces to the ton.

Assay value. The amount of the gold or silver, in ounces per ton ore, as shown by assay of any given sample. **Average assay value.** The weighted result obtained from a number of samples, by multiplying the assay value of each sample by the width of thickness of the ore face over which it is taken, and then dividing the sum of these products by the total width of cross section sampled. The result obtained would represent an average face sample.

Assessment work. The annual work upon an unpatented mining claim on the public domain necessary under the United States law for the maintenance of the possessory title thereto.

Astel Overhead boarding or arching in a mine gallery.

Asteriated quartz. A phenocrystalline variety of quartz having whitish or colored radations within the crystals: called also Star-quartz.

Astyllen. 1. A mine stopping to prevent the flow of water; a dam. 2. A wall to separate ore from waste.

Asymmetrical. 1. Without proper proportion of parts; unsymmetrical. 2. Crystals not divisible into similar halves by a plane; triclinic (Standard). Also used in geology in describing structural features.

Atelene. Lacking the essential form; imperfect. Said of crystals.

Atmosphere. 1. The whole mass of air surrounding the earth. 2. The pressure of air at the sea level used as a unit.

Atmospheric pressure. The pressure of air at the sea level, exerted equally in all directions. The standard pressure is that under which the mercury barometer stands at 760 millimeters. It is equivalent to about 14.7 pounds to the square inch.

Atom.—According to the atomic theory, the smallest particle of an element that can exist either alone or in combination with similar particles of the same or of a different element: the smallest particle of an element that enters into the composition of a molecule.

Atomic weight. The weight of an atom of a chemical element as compared with that of an atom of hydrogen.

Atomization. 1. The method by which a jet of steam, or compressed air, is made to finely divide a fluid, as in an oil-burning furnace. 2. A patent process for producing a metallic dust, as zinc dust.

Atrancar (Mex.). To drill (for blasting) at a very acute angle. (Dwight)

Attrition. Act of rubbing together; friction; act of wearing, or state of being worn; abrasion.

Auerlite. A silico-phosphate of thorium containing about 70 per cent thorium. Like zircon in form.

Augen. The German word for eyes; used as a prefix before various rock names, but more especially gneiss, to describe larger minerals or aggregate of minerals, that are in contrast with the rest of the rock. In gneisses, feldspar commonly forms the augen. They are lenticular with the laminations forking around them, in a way strongly suggesting an eye. The term is seldom used in any other connection than with gneiss in America.

Auger. An instrument for boring or perforating soils or rocks. A carpenter's tool for boring wood. A tool for drilling holes in coal for blasting.

Auger-nose shell. A clearing tool used in boring for coal, etc., having an auger-shaped end.

Auger-stem. The iron rod to which the bit is attached in well drilling.

Auget; Augette. A priming tube, used in blasting.

Augite. The commonest rock-making pyroxene. As distiguished from other pyroxenes augite refers to the dark varieties with considerable alumina and iron. The name is used as a descriptive prefix to many rocks that contain the mineral, as for instance augite-andesite, augite-diorite, augite-gneiss, augite-granite, augite-syenite, etc.

Augitite. Non-feldspathic, porphyritic rocks consisting essentially of a glassy groundmass, with disseminated augite and magnetite. Various minor accessories also occur.

Augitophyric. In petrology, containing distinct crystals of augite.

Aureole. The area that is affected by contact metamorphism around an igneous intrusion.

Authigenous. An adjective coined by Kalkowsky to describe those minerals which form in sediments after their deposition, as, for instance, during metamorphism. The name emphasizes in its etymology the local origin of the minerals as contrasted with that of the other components, the latter having been brought from a distance.

Authigenic. Produced where found; said of the ingredients of crystalline rocks, or of crystalline ingredients of rocks.

Autochthonous. An adjective derived from two Greek words, meaning indigenous. It is applied to those rocks that have originated in situ, such as rock salt, stalagmitic limestones, peat, etc., but it is of rare use.

Autoclastic. Having a clastic or fragmental structure due to crushing or to dynamic metamorphism instead of to sedimentation: said of intraformational conglomerates.

Automatic mine-doors. Doors on a haulage road that are automatically opened by an approaching trip passing over a lever, and that close automatically after the trip has passed through, thus making the services of a door, or trapper-boy unnecessary.

Automorphic. The contrastd term with xenomorphic or allotriomorphic, and is used to describe those minerals in rocks which have their own crystal boundaries. The latter suggested word, idiomorphic, means the same thing and is somewhat more widely used.

Avasite. A black, massive, hydrated iron silicate: probably only siliceous limonite.

Average igneous rock. According to Clarke, the arithmetic mean of all the good analyses should give a fair chemical average for the outermost ten-mile shell of the earth, which represent the composition of an average igneous rock. Authorities differ somewhat from above manner of securing result.

Axe stone. A species of jade. It is a silicate of magnesia and alumina.

Axinite. A boro-silicate of aluminum and calcium with varying amounts of iron and manganese. Exact composition doubtful.

Axis. 1. A straight line, real or imaginary, passing through a body, on which it revolves or may be supposed to revolve; a line passing through a body or system around which the parts are symmetrically arranged. 2. In geology the central or dominating region of a mountain chain, or the line of which follows the crest of a range and thus indicates the position of the most conspicuous part of the uplift.

Axis of Elevation. Line of elevation.

Axis of rotation. The imaginary line about which all the parts of a rotating body turn.

Ayr stone. A fine-grained stone used in polishing marble and giving a fine surface to metal work, particularly iron and steel, also as a whetstone.

Azimuth. The azimuth of a body is that arc of the horizon that is included between the meridian circle at the given place and a vertical plane passing through the body. It is measured (in surveying) from due north around to the right (C. and M. M. P.). In astronomy it is measured from the south to the right i.e. clockwise.

Azoic. Formerly, that part of geologic time represented by the pre-Cambrian stratified rocks; also the rocks formed during that time. Later restricted to the period and system now generally called Archean. Now practically obsolete.

Azote. A name formerly given to nitrogen, because it is unfit for respiration.

Azotine. An explosive consisting of sodium nitrate, charcoal, sulphur and petroleum.

Azure spar. Lazulite.

Azure stone. 1. A synonym for Lapis lazuli. 2. Same as Azurite.

B

Babbitt metal. 1. A soft, white, antifriction metal of varying composition, as of 4 parts of copper, 8 of antimony, and 24 or 96 of tin (the alloy with the smaller proportion of tin being called "hardening," that with the greater "lining"). 2. Any of several alloys similarly used.

Bacharach-American gas indicator. A pocket device for the rapid determination of the percentage of CO_2 in the atmosphere of mines, boiler rooms, blast furnaces, etc.

Back. A joint, usually a strike joint, perpendicular to the direction of working.

Back balance. 1. A kind of self-acting incline in a mine. A balance car is attached to one end of the rope, and a carriage for the mine car is attached to the other. A loaded car is run on the carriage and is lowered to the foot of the incline raising the balance car. The alance car in its descent raises the carriage when the carriage is loaded only with an empty car. 2. The means of maintaining tension on a rope transmission or haulage system, consisting of the tension carriage, attached weight, and supporting structure.

Back fill. In engineering, to fill a depression with material taken from a cutting.

Back filling. 1. Rough material forming the back of a masonry wall. 2. The filling in again of a place from which the earth has been removed; the earth so filled in.

Backing. The timbers fixed across the top of a level, supported in notches cut in the rock.

Backlash. 1. The return or counterblast, as the recoil or backward suction of the air current produced after a mine explosion. 2. The reentry of air into a fan. 3. The lost motion in gearing due to poorly fitted parts, pounds per square inch, due to failure of getting the steam out of the cylinder after it has done its work.

Back pressure. The loss, expressed in pounds per square inch, due to failure of getting the steam out of the cylinder after it has done its work.

Back-pressure valve. A valve similar to a low-pressure safety valve but capable of being opened independent of the pressure, thereby giving free exhaust.

Back shot. A shot usd for widening an entry, placed at some distance from the head of an entry.

Back-slope. In geology, the less sloping side of a ridge. Contrasted with Escarpment, the steeper slope. Called also Structural plain.

Back switching. A zigzag arrangement of railway tracks by means of which it is possible for a train to reach a higher or lower level by a succession of easy grades.

Baffle. That which defeats or frustrates, hence in the flotation process, the projections or wings that divert or interrupt the flow of pulp in a vessel.

Baffle plate. A metal plate used to direct the flames and gas of a furnace to different parts so that all portions of it will be heated; a deflector.

Bag. 1. A paper container 1 to 2 inches in diameter and 8 to 18 inches long, used for placing an inert material such as sand, clay, etc., into a bore hole for stemming or tamping. Also called a Tamping bag. 2. A cavity in a mine containing gas or water.

Bail. The handle of a bucket used for hoisting ore, rock, water, etc., from a mine.

Bailer. A metal tank, or skip, with a valve in the bottom, used for unwatering a mine.

Bala limestone. In Wales, a limestone belonging to the Cambrian system and equivalent to the Trenton in New York, or at least in part.

Balance. The counterpoise or weight attached by cable to the drum of a winding engine to balance the weight of the cage and hoisting cable and thus assist the engine in lifting the load out of the shaft.

Balance car. 1. In quarrying, a car loaded with iron or stone and connected by means of a steel cable with a channeling machine operating on an inclined track. Its purpose is to counteract the force of gravity and thus enable the channeling machine to operate with equal ease up and down hill. (Bowles) 2. A small weighted truck mounted upon a short inclined track, and carrying a sheave around which the rope of an endless haulage system passes as it winds off the drum.

Balance plane. An inclined plane up which empty cars are hoisted by the weight of descending loaded cars. Also called Balance brow.

Ballast. Broken stone, gravel, sand, etc., used for keeping railroad ties in place.

Ballast car. A car used for carrying ballast, which may be unloaded from the side or bottom.

Ballast shovel. A spoon-pointed shovel having a thick body.

Ball breaker. A steel or iron ball that is hoisted by a derrick and allowed to fall on blocks of waste stone for the purpose of breaking them.

Ball clay. A plastic white-burning clay used as a bond in chinaware (Ries). Called also Pipe clay.

Ball grinder. A pulverizer or disintegrator formed by balls of metal inclosed in a rotating cyclinder. The material to be crushed is broken by the attrition of the rolling balls.

Ballistite; Balistite. A smokeless powder consisting essentially of soluble cellulose nitrates and nitroglycerin. It is dark colored and rubbery.

Ball joint. A flexible pipe joint made in the shape of a ball or sphere.

Ball mill. A short tube mill (which see) of relatively large diameter in which grinding is done by steel balls instead of pebbles. The discharge is usually through a screen.

Ball mine. Same as Ball ironstone, I. (Century).

Baltimorite. A grayish-green, silky, fibrous, splintery serpentine: possibly an altered asbestos.

Banakite. A general name given by Iddings to a group of igneous rocks in the eastern portion of the Yellowstone Park, and chiefly in dikes. They are porphyritic and richly feldspathic. The phenocrysts are labradorite and the groundmass consists of alkali-feldspars. A little biotite and subordinate augite may be present.

Band brake. A hand or power-actuated brake of a hoisting engine, consisting of a broad steel band lined with blocks of wood or other material, and which operates against the surface of the winding drum.

Banded structure. A term applied to veins having distinct layers or bands. They may be due to successive periods of deposition, or replacement of some earlier rock.

Banded vein. A vein made up of layers

of different minerals parallel with the walls. Also called Ribbon vein.

Band wheel. The belt wheel on the axis of the drum which drives the walking beam of a well drill.

Bank claim. A mining claim on the bank of a stream.

Bank head. The nearly level upper end of an inclined plane, next to the engine or drum.

Bank to Bank. A shift. The period included between the time a miner arrives at the working face and the time he leaves it.

Bar. **1.** A drilling or tamping rod. **2.** A vein or dike crossing a lode. **3.** A bank of sand, gravel, or other material, especially at the mouth of a river or harbor. **4.** A placer deposit, generally submerged, in the slack portion of a stream (Webster). Accumulations of gravel along the banks of a stream, and, which, when worked by the miners for gold, are called Bar diggings.

Bar drill. A drill similar to the tripod drill, but mounted on a bar supported by four legs.

Bargain. Portion of mine worked by a gang on contract.

Baring. **1.** A making bare; an uncovering. See stripping, 2. **2.** The surface soil and useless strata overlying a seam of coal, clay, iron-stone, etc., which has to be removed preparatory to working the mineral.

Barite. Sulphate of barium, $BaSO_4$; also called Heavy-spar, from its high specific gravity. When finely ground it is used as an ingredient in certain paints, especially in place of white lead. Also called Barytes.

Barium. A chemical element belonging to the group of metals whose oxides are the alkaline earths. It is yellowish white, somewhat malleable, fusible at high temperature, burning easily when heated in air. Sp. gr. 3.6; atomic weight, 137.37; symbol, Ba. The commercial minerals are barite and witherite.

Bar mining. The mining of river bars, usually between low and high waters, although the stream is sometimes deflected and the bar worked below water level.

Barney. A small car, or truck attached to a rope and used to push cars up a slope or inclined plane. Also called Bullfrog, Donkey, Ground hog, Larry, Ram, Mule, and Truck.

Barney-pit. A pit at the bottom of a slope or plane, into which the barney is lowered to allow the mine car to run over it to the foot of the plane.

Barometer. An instrument for determining the weight or pressure of the atmosphere, and hence for judging of probable changes of weather, or for ascertaining the height of any ascent, etc.

Barrandite. A bluish, reddish, greenish, or yellowish-gray hydrous ferric aluminum phosphate.

Barrel. **1.** The water-cylinder of a pump. **2.** A piece of small pipe inserted in the end of a cartridge to carry the squib to the powder. **3.** A vessel used in amalgamation. **4.** The body of a windlass or a capstan about which the cable winds.

Barren. Not containing mineral of value.

Barrier. A solid block or rib of coal, left unworked between two collieries or mines for security against accidents.

Barring-down. **1.** Removing loose rocks in the roof of a mine by means of a bar. **2.** Loosening ore in a bin by means of a bar, so it will flow through the chute.

Barrow tram. A shaft or handle of a wheelbarrow.

Bar Screen. A device for separating different sizes of coal. It consists of a number of parallel inclined bars at regular distances apart along which the coal slides by gravity. See also Grizzly.

Bar-timbering. A system of supporting a tunnel roof by long top bars while the entire lower tunnel-core is taken out, leaving an open space for the masons to run up the arching.

Basal conglomerate. A conglomerate or coarse sandstone forming the lowest member of a series of related strata which lie unconformably on older rocks. It records the progressive encroachment of the sea-beach on the former dry land.

Basalt. A word of ancient but uncertain etymology. It is employed as a rock name in its restricted sense for porphyritic and felsitic rocks consisting of augite, olivine and plagioclase with varying amounts of glassy base which may entirely disappear. In a broader sense the basalt or basaltic group is used to include all the dark, basic, volcanic rocks; such as the true basalts; the nepheline, leucite and melilite-basalts; the augitites and limburgites; the diabases, and melaphyres.

Base line. A line taken as the foundation of operations in trigonometrical and geological surveys.

Basement complex. A series of rocks of great obscurity and complexity beneath the dominantly sedimentary rocks. They are at the bottom of the known series, but since they are not the true base or foundation, they are properly termed the Archean complex.

Basic. In geology, a descriptive term for those igneous rocks that are comparatively low in silica. About 55 or 50 per cent is the superior limit.

Basic rock. A term rather loosely used in lithology; generally to mean one of the following: (a) An igneous rock containing less than 55 per cent of silica, free or combined. (b) An igneous rock in which minerals comparatively low in silica and rich in the metallic bases, such as the amphiboles, the pyroxenes, biotite, and olivine, are dominant. (c) Very loosely, an igneous rock composed dominantly of the dark-colored minerals. In all three senses contrasted with acid.

Basic slag. The slag produced in steel making in the Thomas furnace, in which a basic calcareous or magnesian lining is used in the converter, and lime, either alone or with oxide of iron, is added to the charge of metal. Phosphorous is retained in the slag and carried off.

Basin. **1.** A large or small depression in the surface of the land, the lowest part of which may be occupied by a lake or pond. **2.** An area or tract having certain common features throughout, particularly a tract where the strata dip from all sides toward a center. **3.** A natural depression of strata containing a coal bed or other stratified deposit. **4.** The deposit itself.

Basseting **1.** Outcropping. **2.** The cropping out or appearance of rock on the surface of a stratum, or series of strata.

Bastard. **1.** Of unusual make or proportion; of abnormal shape. **2.** A hard massive bowlder or rock.

Bastard granite. A quarry term for gneissic granites.

Bastard quartz. A miner's term for a white, glassy quartz without other mineralization.

Batholith. A name suggested by Suess for the huge irregular masses of plutonic rocks that have crystallized in depth and that have only been exposed by erosion.

Bath stone. A creamy limestone from the Bath oolite, soft and easily worked. It was used for building in England as early as the 12th century.

Batice. An inclination or bevel given to the upper timbers of a shaft; as the shaft has a downward and outward batice of 1 inch to the foot.

Batten. A strip of wood used for nailing across two other pieces to hold them together or for covering a crack.

Batter. The inclination of a face of masonry or of an inclined portion of a frame or metal structure. Also called Battice.

Battery. See Blasting machine. See Storage battery.

Battery of holes. A number of charges in drill holes, fired simultaneously with an electric current. Also called Multiple shot.

Bearer bar. One of the bars which support the gratebars in a furnace.

Bearing. 1. The course or direction indicated by a compass. 2. The strike or course of a vein. 3. The points of support of a beam, shaft, or axle.

Bearing-up pulley. A pulley wheel fixed in a frame and arranged to tighten or take up the slack rope in endless haulage.

Beat away. A process of working hard ground by wedges and sledge hammers.

Bed. 1. The smallest division of a stratified series, and marked by a more or less well defined divisional plane from its neighbors above and below. 2. A seam or deposit of mineral later in origin than the rock below, and older than the rock above; that is to say, a regular member of the series of formations, and not an intrusion. A deposit, as of ore (or coal), parallel to the stratification. 3. That portion of an outcrop or face of a quarry which occurs between two bedding planes. 4. The level surface of rock upon which a curb or crib is laid. 5. The bottom of a water course, or of any body of water. 6. A mass or heap of anything (as ore), arranged in the form of a bed.

Bedded. Applied to rocks resulting from consolidated sediments, and accordingly exhibiting planes of separation designated bedding planes.

Bedded formation. A formation which shows successive beds, layers, or strata, due to the manner in which it was formed. A bedded deposit.

Bedded vein. Properly "bed vein" (Lagergang of the Germans); a lode occupying the position of a bed, that is, parallel with the stratfication of the inclosing rocks.

Bedding fault. In geology, a dislocation which follows planes of stratification.

Bedford limestone. A light-colored oolitic limestone from Bedford, Indiana.

Bed joint. A horizontal joint.

Bedplate. 1. An iron plate forming the bottom for a furnace. 2. A heavy plate for supporting an engine or other heavy machinery.

Bedrock. The solid rock underlying auriferous gravel, sand, clay, etc., and upon which the alluvial gold rests. Any solid rock underlying soil, sand, clay, etc.

Beds of passage. Beds in which the fossils or rocks, from their resemblance to those contained either in the bed above or the bed below, indicate the transition character of the deposit.

Bedway. An appearance of stratification or parallel marking, in granite.

Beekite. A crytocrystalline variety of quartz, resembling chalcedony, formed by the replacement of limestone, as coral, or shells, with silica.

Before breast. Rock or vein material, which still lies ahead.

Bell. Overhanging rock of bell-like form, not securely attached to the mine roof. "Pot" is the common Arkansas term.

Bell-and-spigot joint. The usual term for the joint in cast iron pipe. Each piece is made with an enlarged diameter or bell at one end into which the plain or spigot end of another piece is inserted when laying. The joint is then made tight by cement, oakum, lead, rubber, or other suitable substance which is driven in or calked into the bell and around the spigot.

Belled. Widened. Said of the enlarged portion of a shaft at the landing for running the cars past the shaft, and for caging.

Bellite. An explosive consisting of five parts of ammonium nitrate to one of metadinitrobenzene, usually with some potassium nitrate.

Bell screw; Screw bell. An internally threaded bell-shaped iron bar, for recovering broken or lost rods in a deep bore hole.

Belt. 1. A zone or band of a particular kind of rock strata exposed on the surface. 2. A continuous strap or band for transmitting power from one wheel to another, or (rarely, to a shaft, by friction).

Benches. A name applied to ledges of all kinds of rock that are shaped like steps or terraces. They may be developed either naturally in the ordinary processes of land degradation, faulting, and the like; or by artificial excavation in mines and quarries.

Bench gravel. (Yukon and Alaska). Gravel beds which occur on the sides of the valleys above the present stream bottoms, representing parts of the bed of the stream when it was at a higher level. Regarded by Tyrell as the terminal moraines of small glaciers.

Bench mark. A mark, the elevation of which is known or assumed and used as a reference point by a surveyor.

Bench working. The system of working one or more seams or beds of mineral by open working or stripping, in stages or steps. Also called Bench-and-bench.

Benchy. Forming frequent benches: said of a lode.

Bending stress. The stress produced in the outer fibers of a rope by bending over a sheave or drum.

Bentonite. A bedded plastic clay which swells very greatly upon wetting.

Berea sandstone. Berea grit. A rock formation consisting of fine-grained sandstone and grit, generally considered as the base of the Carboniferous system in Ohio. It is much used as a building stone and for grindstones, and is one of the principal oil-bearing formations of the State.

Bergmehl; Bergmeal. 1. An infusorial earth, sometimes eaten mixed with meal or bark. Called also Mountain-meal. 2. A white efflorescence of calcite, resembling cotton. Called also Rock-meal and Fossil-farina.

Bevel. A gear wheel whose teeth are inclined to the axis of the wheel.

Bifurcate. To divide into two branches.

Binary granite. A term more or less used in older geological writings for those varieties of granite that are chiefly quartz

and feldspar. It has recently been applied to granites containing two micas.

Binder. 1. Anything which causes cohesion in loosely assembled substances, as cement in a wall, crushed stone in a macadam road, fire clay in a graphite crucible, etc. 3. The course, in a sheet-asphalt pavement, frequently used between the concrete foundation and the sheet-asphalt mixture of graded sand and asphalt cement.

Bin feeder. A man who rods or bars ore that sticks as it passes through the bin door.

Bin man. One who pokes down ore in bins to keep it feeding through the chutes.

Bit. 1. A drilling chisel. Auger-stem. 2. The cuttinig end of a boring implement. 3. A pointed hammer for dressing hard stone, as granite.

Bitter spar. A pure, crystalline dolomite. It consists of one part or equivalent of calcium carbonate and one part of magnesium carbonate. Also called Pearl spar.

Bitulithic. A kind of paving consisting of broken stone cemented with bitumen or asphalt.

Bituminous limestone. A limestone impregnated with bituminous matter and emitting a fetid odor when rubbed. Called also Stinkstone and Swinestone.

Bituminous sandstone. See Sandstone.

Bituminous shale. A shale containing hydrocarbons or bituminous material: when rich in such substances it yields oil or gas on distillation. Called also Pyroschist or Oil Shale.

Black chalk. A variety of blueish-black clay containing carbon.

Black damp. A term generally applied to carbon dioxide. Strictly speaking, a mixture of nitrogen and carbon dioxide. The average black damp contains 10 to 15 per cent carbon dioxide and 85 to 90 per cent nitrogen. It is formed by mine fires and the explosion of fire damp in mines, and hence forms a part of the afterdamp. An atmosphere depleted of oxygen rather than containing an excess of carbon dioxide.

Black horse. A term used by quarrymen in Rhode Island to denote a dark biotite-gneiss in contact with the granite.

Blackjack. 1. A dark variety of zinc-blende or sulphide of zinc. It has a resinous luster and yields a light colored streak or powder. 2. Crude black oil used to lubricate mine-car wheels.

Black lignite. A coal intermediate between lignite and bituminous coal and not always distinguishable from one or the other on sight. Called also Subbituminous coal.

Black oil. A residue from petroleum or from its distillates. It varies widely in character and is used as a cheap lubricant.

Black powder. A granular explosive containing approximately 74 per cent potassium nitrate, 16 per cent wood charcoal, and 10 per cent sulphur.

Black sand. Heavy grains of various minerals which have a dark color, and are usually found accompanying gold in alluvial deposits, e. g., magnetite, chromite, ilmenite, cassiterite, tourmaline, etc.

Blackstone Highly carbonaceous shale.

Blackstrap. A dark, heavy oil used for lubricating mine-car wheels. See also Black jack.

Bladed. Decidedly elongated and flattened. Said of some minerals.

Bladed structure. Consisting of parts resembling knife blades.

Blaisdell reclaiming apparatus. An apparatus for automatically discharging a sand tank having a central bottom opening. It consists of a central vertical shaft carrying four arms fitted with round plow disks. Sand is plowed toward a central opening and discharged on a conveyor belt.

Blaisdell sand distributor. An apparatus for loading sand tanks. It consists of a rapidly revolving disk with curved radial vanes. The disk is hung on a shaft in the center of the tank, and as sand is dropped on the disk it is distributed over the entire area.

Blake crusher. The original crusher of jaw type. A crusher with one fixed jaw plate and one pivoted at the top so as to give the greatest movement on the smallest lump (Richards, p. 1200). Motion is imparted to the lower end of the crushing jaw by toggle joint operated by eccentric.

Blanket shooting. Also termed Buffer shooting or Shooting against the bank. A term applied to a method of blasting on a face not exceeding 30 or 50 feet in height. It involves leaving at the quarry face a mass of shattered rock several feet in thickness that serves as a buffer, preventing the rock from being thrown far from its source, and also rendering the shot more effective.

Blast. 1. The operation of blasting, or rending rock or earth by means of explosives. 2. The air forced into a furnace to accelerate combustion. 3. An explosion of gas (or dust) in a mine.

Blast draft. The draft produced by a blower, as by blowing in air beneath a fire, or drawing out the gases from above it. A forced draft.

Blasted. 1. A term applied to a miner who has been injured by an explosion of dynamite or gunpowder. 2. Rent by an explosive.

Blast hole. A hole for a blasting-charge.

Blast-hole machine. A drilling machine used to drill holes 6 in. diameter and 35 to 40 ft. deep for the purpose of blasting down a large amount of ore or waste in advance of the steam-shovels.

Blasting. 1. The operation of splitting rocks by gunpowder or other explosives: as in mining and quarrying operations. 2. A method of loosening or shattering masses of solid matter, encountered during boring, by means of explosive compounds.

Blasting barrel. A piece of iron pipe, usually about half-inch in diameter, used to provide a smooth passageway through the stemming for the miner's squib. It is recovered after each blast and used until destroyed.

Blasting cap. A copper shell closed at one end and containing a charge of detonating compound, which is ignited from the spark of the fuse. Used for detonating high explosives.

Blasting cartridge. A cartridge containing an explosive to be used in blasting.

Blasting circuit. The leading wires, connecting wires and connected electric blasting caps, when prepared for the firing of a blast.

Blasting compounds. Explosive substances used in blasting.

Blasting fuse. A slow burning fuse used for igniting blasting charges.

Blasting gelatin. A high explosive, consisting of nitroglycerin and nitrocotton. It is a strong explosive, and is a rubber-like, elastic substance, unaffected by water.

Blasting machine. A portable dynamo, in which the armature is rotated by the

downward thrust of the rackbar or handle, used for firing blasts electrically. Also called Battery.

Blasting mat. A tightly woven covering of heavy manila rope or wire rope, or chain, made in various sizes, for covering the material to be blasted and preventing the flying of small fragments of rock.

Blasting needle. A needle-like instrument for making an opening for a fuse (or squib).

Blasting powder. A powder containing less nitrate, and in its place more charcoal than black powder. Its composition is 65 to 75 per cent potassium nitrate, 10 to 15 per cent sulphur and 15 to 20 per cent charcoal. In the United States sodium nirate is largely used in place of the potassium salt.

Blasting stick. A simple form of fuse.

Blasting supplies. A term used to include electric blasting caps, ordinary blasting caps, fuse, blasting machines, galvanometers, rheostats, etc., in fact, everything used in blasting, excepting explosives.

Blast meter. An anemometer for measuring the force of a blast.

Blende. Without any qualification means zincblende or the sulphide of zinc, which has the luster and often the color of common resin, and yields a white streak and powder. The darker varieties are called blackjack by the English miners. Other minerals having this luster are also called blendes, as antimony blende, ruby blende, pitchblende, hornblende.

Blind. Not appearing in an outcrop at the surface; applied to mineral veins.

Blind creek. A creek that is dry, except in wet weather.

Blind drift. A horizontal passage in a mine, not yet connected with the other workings.

Blind lode. A lode showing no surface outcrop, and one that can not be found by any surface indications.

Blind stope. A secret working to remove ore.

Blind vein. A vein that does not continue to the surface.

Blistering. See Secondary blasting; also Mudcap.

Block hole. 1. A small hole drilled in a block of rock either by hand drill or a portable air drill, to contain a small charge of explosive. **2.** A relief hole, designed to remove part of the burden from a subsequent shot, used in coal mining. **3.** A quarryman's term for a method of breaking undesirably large blocks of stone by the discharge of dynamite in shallow holes.

Blockholer. A person whose duty it is to break up and reduce to safe and convenient size, by blasting or otherwise, any large blocks or pieces of rock that have been blown down by the miners.

Blower. 1. A fan or other apparatus. for forcing air into a furnace or mine. **2.** A blowing out or forcible discharge of gas from a hole or fissure in a mine. (Webster).

Blow-George (Eng.). A small centrifugal fan worked by hand, for mine ventilation. (Gresley)

Blowholes. A spot in a casting weakened by a bubble of air; an air hole. (Webster)

Blow-out. 1. A large outcrop, beneath which the vein is smaller, is called a blow-out. **2.** A shot or blast is said to blow out when it goes off like a gun and does not shatter the rock. A blown-out or windy shot. **3.** The cleaning of boiler flues by a blast of steam. (Webster)

Bluestone. The commercial name for a dark bluish-gray feldspathic sandstone or arkose. The color is due to the presence of fine black and dark-green minerals, chiefly hornblende and chlorite. The rock is extensively quarried in New York. Its toughness, due to slight metamorphism, and the ease with which it may be split into thin slabs especially adapt it for use as flagstone.

Blue talc. A synonym for Cyanite. (Chester)

Bluff. A high bank, presenting a precipitous front to the sea or a river. **2.** Blunt.

Boasting. The rough dressing of stone with a boasting chisel.

Bobbin. 1. A catch placed between the rails of the up-line of an incline to stop any runaway trucks. It consists of a bent iron bar, pivoted in such a manner so that the down-hill end is slightly heavier than the up-hill end, which is capable of being depressed by an up-coming truck, but rises above the level of the truck axle as soon as the truck is past. **2.** A spool or reel. (Webster)

Body. 1. An ore-body, or pocket of mineral deposit. **2.** The thickness of a lubricating oil or other liquid; also the measure of that thickness expressed in the number of seconds in which a given quantity of the oil at a given temperature flows through an aperture.

Bog lime. A white powdery, calcareous deposit, precipitated through plant action on the bottom of many ponds and used in Portland cement manufacture. It is often erroneously called marl, a term which properly belongs to a calcareous clay.

Boiler scaler. A man who cleans scales from boiler tubing.

Boiling point. 1. The temperature at which a liquid begins to boil, or to be converted into vapor by bubbles forming within its mass. It varies with the pressure. In water, under ordinary conditions, it is 212° F. or 100° C., but it becomes less with lessened atmospheric pressure, as in ascending a mountain being lowered about 1° F. for every 550 feet of ascent. **2.** The temperature at which crude oil on being heated begins to give forth its different distilates. The boiling point of crude oils and the amounts of distillates obtained at specified temperatures differ considerably.

Bone phosphate. The calcium phosphate obtained from bones; also, in commerce, applied to calcium phosphate obtained from phosphatic rocks, as of North Carolina.

Bonnet. 1. A covering over a mine cage to shield it from objects falling down the shaft. **2.** A cover for the gauze of a safety lamp.

Book clay; Leaf clay. Clay deposited in thin leaf-like laminae. (Power)

Book structure. A peculiar rock structure resulting from numerous parallel sheets of slate alternating with quartz.

Boom. A long spar or beam projecting from the lower end of the mast of a derrick, to support or guide the body to be lifted or swung.

Booster. A small amount of high explosive attached to a detonator for the purpose of increasing the rate of detonation of a charge.

Booster-fan. An additional fan placed at some point in a mine to assist in the ventilation.

Boot. The casing at the lower end of a bucket elevator into which the material to

be elevated is fed.

Bore. 1. To make a hole or perforation with a boring instrument; to cut a circular hole by the rotary motion of a tool, as to bore for water, oil, etc. 2. A hole made by boring. 3. A tidal flood which regularly or occasionally rushes with a roaring noise into certain rivers of peculiar configuration or location, in one or more waves which present a very abrupt front of considerable height, dangerous to shipping. Also a very high aand rapid tidal flow. 4. A borehole; also, a tunnel, especially during its construction.

Borebit. A rock boring chisel.

Borehole. A hole made with a drill, auger or other tools, for exploring strata in search of minerals, for water supply, for blasting purposes, for proving the position of old workings, faults, and letting off accumulations of gas or of water.

Boring. 1. The act of process of making a hole with a boring tool. 2. A hole so made. 3. Material removed by boring.

Boring bar. A revolving or stationary bar carrying one or more cutters or drills for boring.

Boring head. The cutting end of a boring tool, especially the cutter head of a diamond drill.

Boring journal. A book which contains an accurate record of the progress of the boring work, day by day. It is usually kept by the drilling master.

Boring master. A man in charge of a well-boring outfit.

Boring rod. A rod made up of segments, carrying at its lower end a tool for earth boring or rock drilling.

Boron. A nonmetallic element occurring only in combination. May be obtained with difficulty as an olive-green, brown or reddish amorphous mass from its oxide, or as octahedral crystals resembling the diamond in hardness and other properties by heating the amorphous boron with aluminum.

Boss. A domelike mass of igneous rock congealed beneath the surface and laid bare by erosion. The enlarged part of a shaft on which a wheel is keyed, or at the end where it is coupled to another. A cast-iron plate secured to the back of a traveling forge hearth.

Boss driver. One in charge of men or boys who are driving horses or mules for hauling coal, rock, or ore at mines.

Bossing. The holing or undercutting of a thick seam, as of limestone, the height of the undercutting being sufficient for a man to work in.

Bostonite. A rock occurring in dikes, and having the mineralogical and chemical composition of trachyte or porphyry, except that anorthoclase (and therefore soda) is abnormally abundant, and dark silicates are few or lacking. The name was suggested by its supposed presence near Boston, Mass., but Marblehead, 20 miles or more distant, is its nearest locality. It has been found around Lake Champlain and in the neighboring parts of Canada.

Bottle stone. An old name for chrysolite, or any other mineral, which can be melted directly into glass.

Bottom cager. A man at the bottom of a shaft in a mine to superintend the operation of the raising and lowering of the cage.

Bottom filler. A man who fills a barrow with ore, coke, or stone, weighs it and places it on the cage, or elevator to be hoisted to top of the furnace.

Bottoming. 1. The ballasting material for making a roadbed; ballast. 2. The act of fitting with a bottom or performing some basal operation.

Bottom lift. The deepest lift of a mining pump, or the lowest pump.

Bottom lifter. One who digs up the bottom of a drift, entry, or other haulage way to gain head room; also called Brusher; Dirt scratcher; Groundman; Ripper, and Stoneman.

Boulder. See Bowlder.

Boundary. 1. A line between areas of the earth's surface occupied by rocks or formations of different type and age; especially used in connection with geologic mapping, hence, also, a line between two formations or cartographic units on a geologic map. 2. That which indicates or fixes a limit or extent or marks a bound, as of territory.

Bowenite. An unusually hard massive, apple green or greenish-white variety of serpentine.

Bowlder, or Boulder. A fragment of rock brought by natural means from a distance (though this notion of transportation from a distance is not always, in later usage, involved) and usually large and rounded in shape. Cobble stones taken from river-beds are, in some American localities, called bowlders.

Bowlder-belt. A belt of glacial bowlders of many kinds, derived from distant sources and lying transverse to the direction of glacial movement.

Bowlder-clay. The stiff, hard, and usually unstratified clay of the drift or glacial period, which contains bowlders scattered through it; also called Till, Hard-pan, Drift-clay, or simply Drift.

Bowlder-cracker. A heavy iron rod to be dropped upon a rock encountered by the drill in a deep well boring.

Bowlder-fan. A series of bowlder-trains whose lines of direction are divergent.

Bowldering-stone. Smooth translucent flint pebbles, found in gravelpits and used to smooth the faces of emery wheels and glazers by abrading any large grains of emery or other powder on their surfaces.

Bowlder motion. A surface quarry worked only in detached masses of rock overlying the solid rock: sometimes contracted to Motion.

Bowlder-pavement. A zone of bowlders, naturally arranged along a beach, and derived from contiguous beds of bowlder-clay.

Bowlder pop. An alarm given when a bowlder is to be broken up by a pop shot.

Bowlder quarry. A quarry in which the joints are numerous and irregular, so that the stone is naturally broken up into comparatively small blocks. In Tennessee a local term applied to certain marble quarries in the region of Knoxville, where erosion has formed many large cavities and cracks, between which the rock stands up as pinnacles. The cavities are now filled with clay.

Bowlder-train. A train or line of glacial bowlders of the same sort of rock, extending from the source or parent ledge, perhaps for many miles, in the direction of the ice movement.

Box. 1. The part of a wheel which fits the axle. 2. The threaded nut for the

screw of a mounted auger drill. More commonly called boxing.

Box barrow. A large wheelbarrow with upright sides.

Box-bill. A tool used in deep boring for slipping over and recovering broken rods.

Boxing. A method of securing shafts solely by slabs and wooden pegs.

Box timbering. Same as Plank timbering.

Brace head. A cross-attachment at the top of the column of rods in deep boring, by means of which the rods and bit are turned after each drop.

Brake beam. The beam that connects the brake blocks of opposite wheels.

Brake block. That part of a brake holding the brake shoe, or the shoe itself.

Brake hanger. A bar or link suspending brake beams.

Brake horse power. The actual power given out by an engine or other motor calculated from (1) the force exerted on a friction brake, (2) the effective radius of this force, and (3) the speed of the flywheel or brake wheel.

Brake shoe. That part of a brake which rubs against some part of the machine, or some object outside of the machine having a relative motion to the shoe, as a wheel or the ground.

Brash. 1. A mass of loose or broken fragments of rocks resulting from weathering or disintegration on the spot. 2. Brittie.

Brasses. Fittings of brass in bearing blocks, etc., for diminishing the friction of revolving journals that rest upon them.

Brattice. 1. A board or plank lining, or other partition, in any mine passage to confine the air and force it into the working places. Its object is to keep the intake air from finding its way by a short route into the return airway. 2. Planking to support a wall or roof.

Braze. To solder with hard solder which usually is copper and zinc—half and half.

Brea. 1. Sand or soil impregnated with petroleum from seepages, the volatile constituents having evaporated. 2. Maltha or mineral tar.

Breach. 1. An opening made by breaking down a portion of a solid body, as a wall, a dike, or a river bank; a break; a gap. 2. The face of a level or drift.

Breakback. The fractures caused by the shattering of a solid rock ledge back of the drill holes in which the charge is placed.

Breaking-in shot. The first bore hole fired in "blasting off the solid" to provide a space into which material from subsequent shots may be thrown. Also called Opening shot; Buster shot.

Breaking load. The steady and gradually applied load under which a material of construction will break asunder or collapse.

Breaking strain; Breaking strength; Breaking stress. The least load that will break a rope. These terms are used indiscriminately to mean the load that will break a rope. The stress on a rope at the moment of breaking is the breaking stress, and the strain or deformation produced in the material by this stress is the breaking strain.

Breast. The face of a working. That part of the bedplate which is back of the crossheads in engines of the Corliss type.

Breast auger. An auger supported by a breast plate against the miner's body. Used for drilling holes in soft coal.

Bread-heads. Natural joints in rock, coal, etc.

Breast holes. Relief holes used in tunneling, and which are fired after the bottom cut.

Breast stoping. A method of stoping employed on veins where the dip is not sufficient for the broken ore to be removed by gravity. The ore remains close to the working-face and must be loaded into cars at that point.

Breccia. A fragmental rock whose components are angular and therefore, as distinguished from conglomerates, are not water-worn. There are friction or fault breccias, talusbreccias and eruptive breccias.

Breeching. The sheet-iron casing at the end of boilers to convey the smoke from the flues to the smokestack.

Bridge. A low separating wall, usually of fire brick, in a reverberatory furnace between the hearth and the grate (fire bridge) or sometimes between the hearth and the flue (flue bridge.) Often called bridge wall.

Bridge wire. The fine platinum wire which is heated by the passage of an electric current to ignite the priming charge of an electric blasting cap, an electric squib or similar devices.

Bridle bar. The transverse bar connecting the points of a tramway switch.

Bridle chains. Safety chains to support the cage if the shackle should break, or to protect a train of cars on a slope should the shackle or drawbar fail.

Bridle iron. A strong flat iron bar so bent as to support, as in a stirrup, one end of a floor timber, where no sufficient bearing can be had.

Bridle rod. An iron tiebar used to join the ends of two switch rails to hold them to gage. A bridle bar.

Briggs' standard. A list of pipe sizes, thickness, threads, etc., compiled by Robert Briggs about 1862 and subsequently adopted as a standard.

Bright rope. Rope of any construction, whose wires have not been galvanized, tinned, or otherwise coated.

Brimstone. A common name for sulphur.

British thermal unit. The 1/180 quantity of heat required to raise the temperature of one pound of water from 32° to 212° F.; substantially equal to that required to raise the temperature of one pound of water from 63° to 64° F. Abbreviated as B. t. u.

Broach. 1. A sharp-pointed chisel for rough-dressing of stones. 2. A reamer. 3. To shape roughly, as a block of stone, by chiseling with a coarse tool.

Broaching-bit. A tool used to restore the dimensions of a bore hole which has been contracted by the swelling of the marl or clay walls; also used to break down the intervening rock between two contiguous drill holes. A reamer.

Broken charge. A charge of explosive in a drill hole divided into two or more parts that are separated by stemming.

Brontolith. A meteoric stone; a thunderstone.

Brown spar. Any light carbonate, colored brown by the presence of iron oxide, as ankerite, dolomite, magnesite, or siderite.

Brownstone. A dark-brown sandstone from quarries in the Triassic, especially from the Connecticut River valley.

Brucite. Hydrated magnesium oxide, $MgO.H_2O$.

Brunton. A small pocket compass with sights and a reflector attached, used in

sketching mine workings, as in mine examinations, or in preliminary surveys.

Brushing shot. 1. A charge fired in the air of a mine to blow out obnoxious gases, or to start an air current. 2. A shot so placed as to remove a portion of the roof to increase height of a haulage way.

B. t. u. An abbreviation for British thermal unit.

Buck. 1. To break up or pulverize, as ores. 2. To carry, as to buck water.

Bucket dredge. A dredge in which the material excavated is lifted by an endless chain of buckets.

Bucket line. The series of joined buckets forming part of the digging apparatus of a dredge.

Bucket pump. 1. A lifting pump. 2. An iron or wooden receptacle for hoisting ore, or for raising rock in shaft sinking.

Buckling. The act of bending; tendency to bend or become wavy.

Buffer. 1. An elastic apparatus or fender for deadening the jar caused by the collision of bodies. Anything serving to deaden a shock.

Buffer shooting. Same as Blanket shooting.

Bug hole. A small cavity, in a rock, usually lined with crystals.

Bulkhead. 1. A tight partition or stopping in a mine for protection against water, fire, or gas. 2. The end of a flume, whence water is carried in iron pipes to hydraulic workings.

Bull bit. A flat drill bit.

Bulldoze. To reduce broken rock by the use of explosives to a size handy for raising to the surface.

Bullfrog. See Barney.

Bulling. 1. The dislodging of rock by exploding blasting charges in fissures. 2. Lining a shot hole with clay.

Bulling bar. An iron bar used to pound clay into the crevices crossing a bore hole, which is thus rendered gas-tight (Ihlseng). Compare Bull, 1.

Bull wheel. 1. In drilling, a wheel on which the bull rope is wound. 2. An underground sheave wheel. Particularly the wheel around which the tail rope is passed beyond each terminal of a tail-rope haulage system.

Bullying. See Springing.

Bumping post. A post placed as a buffer at the end of a spur of railroad track.

Bunker Hill screen. A rotating screen shaped like a funnel. Material is delivered inside the funnel, the undersize passing through the screen, while the oversize is discharged through the funnel neck.

Buntons. Timbers placed horizontally across a shaft. They serve to brace the wall-plates of the shaft-lining, and also, by means of plank nailed to them, to form separate compartments for hoisting or ladder-ways.

Burden. 1. Valueless material overlying the ore, especially such as is removed by stripping. Frequently called Overburden. 2. The distance between the charge and the free face of the material to be plasted.

Burning point. The temperature at which a volatile oil in an open vessel will ignite from a match held close to its surface.

Burrstone. A cellular but very compact siliceous rock from which the best millstones are made.

Bursting charge. A small charge of fine powder, placed in contact with a charge of coarse powder to insure the ignition of the latter.

Burton. Any of several kinds of tackle, usually one with a single and double block.

Bus bar. A copper or aluminum conductor used in electric lighting or power stations to receive the current from all the dynamos, or distribute it to the motors, etc.

Bushing. A pipe fitting for the purpose of connecting a pipe with a fitting of larger size, being a hollow plug with internal and external threads to suit the different diameters.

Bush metal. An alloy used for journals, bearings of shafts, etc.

Bustamite. A grayish-red variety of rhodonite containing lime.

Butte. A conspicuous isolated hill or small mountain, especially one with steep or precipitous sides.

Butt-entry. The gallery driven at right-angles with the butt cleat. An end-on entry.

Butterfly. 1. The name applied to certain valvés made after the design of a damper in a stove pipe. 2. In pumps this term signifies a double clack-valve whose flaps work on a diametral hinge, like the wings of a butterfly.

By-pass; Bye-Pass. A short passage used to get by or around a place it is not advisable to cross, e. g., a mine shaft.

By-wash. A channel cut to convey the surplus water from a reservoir or an aqueduct, and prevent overflow.

C

Cable. 1. Same as a cable-laid rope; a fiber cable consists of three hawsers laid up left-handed. 2. A bundle of insulated wires, insulated by an outside wrapping. forming a water-proof electrical conductor, as a submarine cable. 3. A steel rope for hoisting or for aerial trams.

Cable-laid rope. Wire cables made of several ropes twisted together, each rope being composed of strands twisted together without limitation as to the number of strands or direction of twist. A fiber cable-laid rope is composed of strands of hawser-laid rope, twisted right-handed.

Cable tools. The apparatus used in drilling deep holes with a rope instead of rods, to connect the drill with the machine on the surface.

Cabocle. A compact rolled pebble resembling red jasper, supposed to be hydrous aluminum-calcium phosphate: found in the diamond-producing sands of Bahia, Brazil.

Caen stone. A light cream-colored Jurassic limestone, chiefly from Caen, Normandy, largely used in carved architectural work.

Cage. 1. A frame with one or more platforms for cars, used in hoisting in a vertical shaft. It is steadied by guides on the sides of the shaft. 2. A structure of elastic iron rods slipped into the bore-hole in rod-boring to prevent vibration of the rods. 3. The barrel or drum of a whim on which the rope is wound.

Cage guides. Vertical pieces of wood, iron, or steel, fixed in a shaft, between which cages run, and whereby they are prevented from striking one another, or against any portion of the shaft.

Cage seat. Scaffolding, sometimes fitted with strong springs, to take the shock, and on which the cage rests when reaching the pit bottom, or other landing.

Calcarenite. A name suggested by A. W.

Grabau for a "limestone or dolonite composed of coral or shell-sand or of calcic sand derived from the erosion of older limestones."

Calcareous. Consisting of or containing carbonate of calcium.

Calcareous grits. Sandy beds, intermixed with calcareous matter.

Calcareous sandstone. A sandstone containing a considerable proportion of calcium carbonate.

Calcareous spar. Crystallized carbonate of calcium.

Calcareous tufa. A spongy, porous or vesicular deposit of calcium carbonate. When the carbonate of calcium is deposited in a solid form it is called travertine or calc-sinter. Stalactites and stalagmites are of this nature.

Calcic. Of, pertaining to, or containing calcium. Said especially of minerals, particularly feldspars, of which calcium is an important constituent, and of igneous rocks which are characterized by the presence of such minerals.

Calciferous. Bearing, producing, or containing, calcite, or carbonate of calcium.

Calcilutite. A name suggested by A. W. Grabau for a limestone or dolomite made up of calcareous rock flour, the composition of which is typically nonsiliceous, though many calcilutites have an intermixture of clayey material.

Calcination. The reduction of ore or other material to a calx or friable condition by the action of fire.

Calcine. To expose to heat, with or without oxidation; to roast. Applied to ores for the removal of water and sulphur, and the disintegration of the mass; to limestone for the expulsion of its carbon dioxide; etc.

Calciner. A furnace or kiln for roasting.

Calcining furnace. A furnace used for roasting ore in order to drive off certain impurities.

Calcirudite. A name suggested by A. W. Grabau for a "limestone or dolomite composed of broken or worn fragments of coral or shells or of limestone fragments, the interstices filled with calcite, sand, or mud, and with a calcareous cement."

Calcite. Hexagonal (rhombohedral) calcium carbonate, the more common form of $CaCO_3$. Contains 56 per cent lime, CaO.

Calcium. A silver-white, rather soft metal of the alkaline earth group. Symbol, Ca; atomic weight, 40.07. Specific gravity, 1.56.

Calcium carbide. A crystalline solid, CaC_2, colorless when pure, but often resembling gray limestone. It is made by heating lime and carbon together in the electric furnace, and is used for the generation of acetylene.

Calcium carbonate. A solid, $CaCO_3$, occurring in nature, as calcite, etc.

Calcium chloride. A compound, $CaCl_2$, crystallizing usually with six molecules of water.

Calcium fluoride. The compound, CaF_2, occurring in nature as fluorite.

Calcium hydroxide. Slaked lime, $Ca(OH)_2$.

Calcium sulphate. See Anhydrite; Gypsum.

Calcomalachite. A form of malachite containing calcite and gypsum; used as an ornamental stone.

Calc-schist. A schistose rock, rich in calcite or dolomite, forming intermediate or transitional rock between the mica-schists and crystalline limestones.

Calc-sinter. Limestone deposited from springs and waters containing it; travertine.

Calc-spar. A synonym for Calcite.

Calculiform. Pebble-shaped.

Caliber. The inner diameter or bore of a tube or pipe.

California pump. A rude pump made of a wooden box through which an endless belt with floats is operated; used for pumping water from shallow ground.

Calk. To drive tarred oakum into the seams between planks and fill with pitch.

Calking tool; Calking iron. A blunt-ended chisel used in calking.

Callimus. Loose, stony matter found in the cavities of eaglestone.

Callow cone. A conical settling tank with vertical central feed, peripheral overflow, annular launder to collect and convey away the overflow, and a spigot in the form of a gooseneck to discharge the tailings.

Callow screen. A classifying screen using the traveling-belt principle, the screen cloth forming the belt member. It passes over two drums, or pulleys, oversize being discharged while the belt travels under the drums.

Calorie. The amount of heat required to raise the temperature of one gram of water one degree centigrade at or near the temperature of maximum density.

Calorimeter. Any apparatus for measuring the quantity of heat generated in a body or emitted by it, as by observing the quantity of a solid liquified, or of a liquid vaporized, or the amount of heat absorbed by a certain quantity of water, under given conditions.

Calx. 1. Lime. 2. The friable residue left when a metal or mineral has been subjected to calcination. Metallic calxes are now called oxides.

Camstone. A compact, whitish limestone.

Canch. A part of a bed of stone worked by quarrying.

Cannon-ball mill. A mill for grinding tough materials by attrition with cannon balls in a rotating drum or chamber.

Cant. 1. To slip or turn over to one side. 2. An inclination from a horizontal, vertical, or other given line; a slope or bevel; a tilt.

Cant hook. A wooden lever with a movable iron hook at the end used for canting or turning over logs or timbers.

Capacity of air compressor. The actual amount of air compressed and delivered, expressed in terms of free air at intake temperature and at the pressure of dry air at the suction. The capacity of an air compressor should be expressed in cubic feet per minute.

Cap Crimper. See Crimper.

Capstan. A vertical axle used for heavy hoisting, and worked by horizontal arms or bars.

Capstan bar. One of the levers by which a capstan is worked.

Carbodynamite. A form of dynamite in which fine charcoal is used as the absorbent.

Carbon monoxide. A colorless, odorless gas, CO. It is the product of incomplete combustion of carbon. It burns with a pale-blue flame forming CO_2. It is very poisonous to animals, since it combines with the haemoglobin of the blood, expelling oxygen. Also known as White damp.

Carbonolite. Wadsworth's name for carbonaceous rocks.

Carbon steel. Steel deriving its qualities

from carbon chiefly, without the presence of other alloying elements.

Carborundum. A crystalline compound, SiC, consisting of silicon and carbon. It is produced in an electric furnace and used as an abrasive.

Car dumper. A mechanical device for tilting a railroad hopper or gondola car over sidewise and emptying its contents.

Car haul. An endless chain or cable arranged to haul the cars automatically up a slope, from the top of which the cars may travel by gravity.

Carnotite. A canary-yellow mineral, somewhat variable in composition, containing uranium and vanadium, with either or both lime and potash.

Cartographic. Pertaining to a map. In geology a cartographic unit is a rock or group of rocks that is shown on a geologic map by a single color or pattern.

Cartridge pin. A round stick of wood on which the paper tube for the blasting cartridge is formed.

Car trimmer. A person who adjusts the load in a car.

Case markings. The letters or figures stenciled or printed on the front of a case containing explosives indicating the size, weight, kind, strength, date, and place of manufacture.

Castellanos powder. A kind of blasting powder containing nitroglycerin and either nitrobenzene or a pictrate, mixed with other materials.

Casting over. A quarryman's term for an operation consisting of making a cut with a steam shovel, which, instead of loading the material on cars, moves it to one side, forming a long ridge.

Cataclasm. A breaking or rending asunder; a violent disruption.

Cataclastic. Having a fragmental texture due to crushing during dynamic metamorphism: said of certain metamorphic rocks.

Cataclinal. Extending in the direction of the dip: said of a valley.

Catawbrite. A name given by O. Lieber to a rock in South Carolina that is an intimate mixture of talc and magnetite.

Catchall. A tool for extracting broken implements from drilled wells.

Cat gold. An early name for gold-colored mica.

Cathead. 1. A small capstan. **2.** A broad-bully hammer.

Cathode. The negative terminal of an electric source, or more strictly, the electrode by which the current leaves the electrolyte on its way back to the source.

Cat hole. A small hole dug in rock for the point of a tripod leg of a machine drill.

Cat's brain. Sandstones traversed in every direction by little branching veins of calcite.

Cave deposits. Irregular deposits of material in the caves generally found in limestone.

Cavern limestone. Any limestone abounding in caverns, especially the Carboniferous limestone of Kentucky.

Cement mill. A mill for crushing and grinding cement stone; also a mill for grinding the cinder after it comes from the kiln.

Cement rock. An argillaceous limestone used in the manufacture of natural hydraulic cement. Contains lime, silica, and alumina in varying proportions, and usually more or less magnesia.

Cement stone; Cement rock. Any rock which is capable of furnishing cement when properly treated.

Centrigrade. Consisting of a hundred divisions. The centigrade thermometer has zero, 0°, as the freezing point of water and 100° as the boiling point. To convert centrigrade thermometer readings to Fahrenheit readings multiply the former by 1.8 and add 32°.

Centrifugal pump. A form of pump which displaces fluid by whirling it around and outwardly by vanes rotating rapidly in a closed case.

Centripetal pump. A pump with a rotating mechanism that gathers a fluid at or near the circumference of radial tubes and discharges it at the axis.

Chain grate. A feeding device for furnaces.

Chairs. Movable supports for the cage arranged to hold it at the landing when desired.

Chalcites. A term used by M. E. Wadsworth to include lime, mortar, cement, etc., used as building materials.

Chalk. A fine-grained, soft, white, friable variety of limestone composed of the shells of various marine animals.

Channeler. A material for cutting stone in rock excavating where smooth sides are desired. A channeling machnie.

Chaplet. 1. A machine for raising water, or for dredging, by buckets on an endless chain passing between two rotating sprocket wheels. **2.** A chain pump having buttons or disks at intervals along its chain; paternoster pump. **3.** A device for holding the end of heavy work, as a cannon, in a turning lathe.

Charge. 1. The explosive loaded into a bore hole for blasting; also any unit of an explosive, as a charge of nitroglycerin or a charge of detonating composition in the blasting cap. **2.** To put the explosive into the hole, to arrange the fuse, or squib, and to tamp it. **3.** The materials introduced at one time or one round into a furnace.

Chaser. An edge wheel revolving in a trough to crush asbestos mineral without destroying the fiber. Also called Edge runner, and used in the pottery industry, and for fine crushing of ore.

Chat-roller. An ore-crushing machine, consisting of a pair of cast-iron rollers, for grinding roasted ore.

Chats. 1. Small pieces of stone with ore. Also middlings which are to be crushed and subjected to further treatment. The mineral and rocks mixed together which must be crushed and cleaned before sold as mineral. Chats are not the same as tailings, as the latter are not thrown aside to keep for future milling. **2.** Loosely used in Missouri for tailings or waste product from the concentration of lead and zinc ore.

Chatter mark. One of a series of short curved cracks on a glaciated rock surface. The individual cracks are transverse roughly to the striae, but the course of a series of chatter marks is parallel to the striae.

Check valve. An automatic nonreturn valve; or a valve which permits a fluid to pass in one direction, but automatically closes when the fluid attempts to pass in the opposite direction.

Chert. A compact, siliceous rock formed of chalcedonic or opaline silica, one or both, and of organic or precipitated origin. Chert occurs distributed through limestone, affording cherty limstones. Flint is a variety of chert.

Chilean mill; Edge runner. A mill having veritcal rollers running in a circular enclosure with a stone or iron base or die. There are two classes: (a) those in which the rollers gyrate around a central axis, rolling upon the die as they go (the true Chilian mill); (b) those in which the enclosure or pan revolves, and the rollers placed on a fixed axis, are in turn revolved by the pan. It was formerly used as a coarse grinder, but is now used for fine grinding.

Chilled dynamite. The condition of the dynamite when subjected to a low temperature not sufficient to congeal it, but which seriously affects the strength of the dynamite.

Chimney shot. A local term applied to the effect of an overcharge of explosive in a line of drill holes, the effect being to throw the rock to some distance, forming a deep trench.

Chisel. See Bit.

Chlorate powder. A substitute for black powder in which potassium chlorate is used in place of potassium nitrate. This class of explosive has received little attention on account of greater sensitiveness to shock and friction.

Chlorine minerals. Minerals containing chlorine, such as atacamite, boracite, apatite, carnallite, cerargyrite, halite, mimetite, pyromorphite, salammoniac, sylvite, sodalite, vanadinite, wernerite, etc.

Chlorite. 1. A silicate of aluminum with ferrous iron and magnesium and chemically combined water, characterized by the green color common with silicates in which ferrous iron is prominent. 2. A general name for the green, secondary, hydrated silicates, which contain aluminum and iron, and which are especially derived from augite hornblende, and biotite. Chlorite is used as a prefix for various names of rocks that contain the mineral, such as chlorite schist.

Chlorite slate. A schistose or slaty rock consisting largely of chlorite.

Chloritic sand. Sand colored green by chlorite as a constituent.

Choke crushing. A recrushing of fine ore due to the fact that the broken material cannot find its way from the machine before it is again crushed.

Chrysotile. Fibrous serpentine.

Chuck. 1. That part of a machine drill which grips or holds the drill. 2. A device for holding an object so that it can be rotated, as upon the mandrel of a lathe or for fixing it in a drill-press, planer, etc.

Churn drill. 1. Also called Cable drill or Well drill. A portable drilling equipment usually mounted on four wheels and driven by gasoline, electricity, or steam. Also applied to a stationary drill operated from a derrick as in oil-well drilling. The drill head is raised by means of a rope or cable and allowed to drop, thus striking successive blows by means of which the rock is pulverized and the hole deepened. 2. A long iron bar with a cutting end of steel, used in quarrying, and worked by raising and letting it fall. When worked by blows of a hammer or sledge, it is called a "jumper."

Chute. (Sometimes written shoot). A channel or shaft underground, or an inclined trough above ground, through which ore falls or is "shot" by gravity from a higher to a lower level.

Chute caviing. The method involves both overhand stoping and ore caving. The chamber is started as an overhand stope from the head of a chute and is extended up until the back weakens sufficiently to cave.

Chute system. See Glory hole system.

C. I. F. A commercial transportation term meaning "Cost, Insurance, and Freight." It is intended to cover the cost of certain goods at point of destination. Usually applied only to maritime freight.

Cinder. 1. Slag, particularly from iron blast furnaces. 2. A scale thrown off in forging metal. 3. Scoriaceous lava from a volcano; volcanic scoria.

Circuit breaker. An automatic device for breaking an electric circuit at the highest current which it may be called upon to carry.

Claim. The portion of mining ground held under the Federal and local laws by one claimant or association, by virtue of one location and record.

Clamp kiln. A kiln built of sods for burning lime.

Clamshell. A hinged, two leaved self-loading scoop used in dredges, coal-ore, and ash-loaders, and hoisting machinery.

Clasolite. A rock composed of other rock fragments.

Classifier. 1. A machine for separating ore from gangue or for cleaning coal from slack. 2. A machine for grading the feed to concentrators so that each individual concentrator will receive its proper feed. Classifiers may be hydraulic or surface-current box classifiers. Classifiers are also used to separate sand from slime, water from sand, and water from slime.

Clastic. A descriptive term applied to rock formed from the fragments of other rocks; fragmental.

Claying bar. A rod used for making a blast hole water-tight by driving clay into its crevices, in order to protect the charge.

Clay-iron. An iron rod used for ramming clay into wet drill holes.

Clay rock. A rock made up of fine argillaceous detrital material and chiefly that derived from the decomposition of the feldspars; indurated clay, sufficiently hardened to be incapable of using as a clay without grinding, but not chemically altered or metamorphosed.

Clay shale. Shale composed wholly or chiefly of argillaceous material, which again becomes clay on weathering.

Clearance. 1. The space between the piston at the end of its stroke and the valve face, or the end of the cylinder. 2. The space between the top or side of a car and the roof or wall.

Cleavage. In petrology, a tendency to cleave or split along definite, parallel, closely spaced planes, which may be highly inclined to the bedding planes. It is a secondary structure, commonly confined to bedded rocks, is developed by pressure, and ordinarily is accompanied by at least some recrystallization of the rock.

Clinker. 1. The product of the fusion of the earthy impurities (ash) of coal during its combustion. 2. A scale of black oxide of iron formed when iron is heated to redness in open air.

Clipper-off. (Aust.). A boy who unfastens the clip connecting a skip to a haulage rope. (Power)

Close connected. Applied to dredges in which the buckets are each connected to the one in front without any intermediate link.

Clearance. 1. The space between the

piston at the end o fits stroke and the valve face, or the end of the cylinder. 2. The space between the top or side of a care and the roof or wall.
clined to the bedding planes. It is a secon-

Clucking. The breaking of a rock by curved fractures that pass beyond the limit of the desired plane of separation.

Cobblestone. A smoothly rounded stone, larger than a pebble and smaller than a bowlder.

Cohesion. That force by which molecules of the same kind or of the same body are held together, so that the body resists being pulled to pieces.

Coil drag. A tool to pick up pebbles, bits of iron, etc., from the bottom of a drill hole.

Colloid. A state of matter supposed to represent a degree of subdivision into almost molecular dimensions, dispersed in a solvent. Colloidal particles possess the property of carrying electric charges, and also of failing to diffuse through a membrane, this being the original distinction between colloids and crystalloids.

Collophanite. A dull, colorless or snow-white hydrous calcium phosphate, $Ca_3P_2O_8 + H_2O$.

Colluvial. Consisting of alluvium in part and also containing angular fragments of the original rocks. Contrasted with Alluvial and Diluvial.

Columbia group. A series of fluvioglacial marine and estuarial deposits of sand and gravel, overlying the Lafayette formation along the Atlantic coast of the United States south of New York, formed in the Pleistocene during the final glacial retreat.

Columnar structure. 1. A mineralogical structure made up of slender columns, as in some amphibole. 2. A structure common in dikes, sills, and lava sheets, consisting of parallel, more or less regular, prismatic columns, generally transverse to the rock.

Combination shot. A blast made by dynamite and permissibles or permissible explosives and blasting powder in the same hole. It is bad practice and in many States is prohibited by law.

Combination stoping. See combined and underhand stoping.

Combined overhand and underhand stoping. This term signifies the workings of a block simultaneously from the bottom to its top and from the top to the bottom. The modifications are distinguished by the support used—open stopes, stull-supported stopes or pillar-supported stopes. Also known as Combined stopes, Combination stoping, Overhand stoping and milling system, and Back and underhand stoping milling system.

Combined shrinkage stoping and block caving. Also called Overhand stoping with shrinkage and simultaneous caving. In this method the ore-body is worked from the top down in successive layers of much greater thickness than in top slicing. The mass of ore is weakened by a series of shrinkage stopes, which are extended up between the ribs, pillars, or blocks, which are subsequently caved. The intervening blocks are undercut and caved as in block caving. The cover follows the caved ore.

Combined top slicing and shrinkage stoping. In this method the orebody is worked from the top down in successive slices. In the working of each slice the unit is worked as a shrinkage stope. The broken ore serves to give lateral support to the sides of the unit and also serves as a working platform from which the back is reached. After working a unit the cover is caved. No timber mat is used. Also known as the Kimberly method.

Combustion chamber. A space over or in front of furnace where the gases from the fire become more thoroughly mixed and burnt.

Come-along. A gripping device as for stretching wire, consisting of two paws so attached to a ring that they are closed by putting on the ring.

Comminute. To reduce to minute particles, or to a fine powder; to pulverize; triturate.

Common iron. The poorest quality of commercial iron.

Commutator. 1. A device for reversing the direction of an electric current, as through the primary circuit of an induction coil. 2. An attachment for the armature of a dynamo for commutating or rectifying the induced currents in the armature conductors.

Commuting transformer. A transformer resembling a dynamo but with a revolving commutator, the other parts being stationary.

Compression efficiency. The ratio of the work required to compress isothermally all the air delivered by an air compressor to the work actually done within the compressor cylinder, as shown by indicator cards, and may be expressed as the product of the volumetric efficiency (the intake pressure and the hyberbolic logarithm of the ratio of compression), all divided by the indicated mean effective pressure within the air cylinder or cylinders.

Concentrating plant. See Concentrator.

Concrete. A mixture of sand, gravel, pebbles, or stone chippings, with cement or with tar, etc., used for sidewalks, roadways, floors, foundations, etc.

Conglomerate. An aggregate of rounded and water-worn pebbles and bowlders cemented together into a coherent rock. Deposited by streams or waves, generally with some sorting and stratification. Compare Breccia.

Conical drum. The drum of a winding engine, constructed in the form of two truncated cones placed base to base, the outer ends being usually the smaller in diameter. It may also be a single cone.

Connecting. The operation of joining adjacent electric blasting cap wires to each other, to connecting and leading wires, in such a way that an electric current will flow through with the least possible resistance.

Connecting wire. A wire of smaller gauge than the leading wire used for connecting the electric blasting-cap wires from one bore hole to those of an adjoining one.

Convulsion. A sudden and violent disturbance of the order of the rocks; a terrestrial catastrophe; cataclysm.

Copi. Gypsum, generally weathered.

Coral limestone. A limestone composed of coral fragments. Such a rock is much used in the Bermuda Islands.

Coralline. Pertaining to, composed of, or having the structure of corals; as coralline limestone.

Coralloidal. Like coral, or consisting of interlaced flexuous branchings. (Dana)

Cordeau. A trade name for a type of detonating fuse consisting of trinitrotoluene inclosed in a lead tube.

Cordierite. A magnesium-iron-alumninum silicate. Sometimes used as a gem. A synonym of iolite or dichroite, employed as

a prefix to those rocks that contain the mineral, as cordieritegneiss.

Cordite. An explosive of nitroglycerin and a dope, used chiefly as a propellant.

Core. A cylinder-shaped piece of rock produced by a core-drill. 2. The central part of a rope forming a cushion for the strands. In wire ropes it is sometimes made of wire, but usually it is of hemp, jute, or some like material.

Core bit. A hollow cylindrical boring bit for cutting out a core in earth boring or rock drilling. In operation it is attached to and forms part of the core drill.

Core drill. A dimond or other hollow drill for securing cores.

Core lifter. An instrument used to bring up the core left by an annular bit in a boring.

Core snatcher. A company man who collects and takes care of drill cores when the drilling is being done by contract.

Cornish engine. A single-cylinder, single-acting beam engine using steam expansively and regulated by an hydraulic control.

Cornish pump. A pump operated by rods attached to the beam of a single-acting, condensing beam-engine. The steam, pressing down the piston in the vertical steam cylinder, lifts the pump rods, and these subsequently descend by their own weight.

Cornstone. A reddish or bluish-red concretionary limestone. Its decompostion is said to produce a good soil for the cultivation of corn, being so different from the cold, stiff, clayey soils formed over the marls. Also called Cornbrash.

Corrugated. When beds on a small scale are much wrinkled, folded or crumpled, they are said to be corrugated. On a larger scale they are said to be contorted.

Cow. A kind of self-acting brake for inclined planes; a trailer.

Coyote hole. Same as gopher hole. A small tunnel driven horizontally into the rock at right angles to the face of the quarry. It has two or more cross-cuts driven from it parallel to the face. It is in the ends of the cross-cuts that the explosive charge is generally placed, and the remaining space in the tunnel is filled up with rock, sand, timbers, or concrete, to act as stemming or tamping.

Coyoting. Mining in irregular openings or burrows, comparable to the holes of coyotes or prairie foxes.

Cramp. 1. A short bar of metal having its two ends bent downwards at right angles for insertion into two adjoining pieces of stone, wood, etc., to hold them together. 2. A pillar of rock or mineral left for support.

Crane. A kind of machine for raising holding them suspended, transporting them through a limited lateral distance.

Crane man. A man who operates any type of a crane.

Crane Post. The upright post on which the arm or jibe or a crane works.

Cretaceous. Of the nature of chalk; relating to chalk.

Crimp. The flattening made by a crimper near the mouth of a blasting cap for holding the fuse in place.

Crimper. A device used for crimping a cap about a piece of fuse.

Crop. 1. See Outcrop. 2. The roof coal or stone which has to be taken down in order to secure a safe roof in the workings.

Crop out. To be exposed at the surface; referring to strata.

Cross-bedded. Characterized by minor beds or laminae oblique to the main stratification; cross-stratified.

Cross-bedding. Lamination, in sedimentary rocks, confined to single beds and inclined to the general stratification. Caused by swift, local currents, deltas, or swirling wind-gusts, and especially characteristic of sandstones, both aqueous and eolian.

Cretaceous. Of the nature of chalk;

Cross Course. A seam, bar or belt of rock, not necessarily a load, crossing a lode. A contra-lode.

Crosscut method of working. See Overhand stoping.

Crosscut tunnel. A tunnel driven at approximately right angles to a main tunnel, or from the bottom of a shaft or other opening, across the formation to an objective point.

Cross fault. An oblique or dip fault.

Cross-grained rock (Ohio). A local term for certain sandstone beds that exhibit cross bedding.

Cross-stratification. In geology, the condition of having the minor laminations oblique to the plane of the main startum which they help to compose.

Crowfoot; Crow. 1. A tool with a side-claw, for grasping and recovering broken rods in deep bore-holes. 2. An iron claw or fork, to which a rope is attached, and by which the rods are lowered and raised when changing the tools in deep bore holes.

Crown arch. The arched plate which supports the crown-sheet of the fire box of a boiler.

Crown bar. One of the bars on which the crown-sheet of a locomotive rests.

Crown sheet. The flat plate which forms the top of the furnace or fire box in an internally fired steam boiler.

Crown tree; Crown. A piece of timber set on props to support the mine roof.

Crushed vein. A mineral zone or belt of crushed material. The crushing is due to folding, faulting, or shearnig.
or other materials. As a gyratory crusher, jaw crusher, stamp mill, etc.

Cruesher rolls. See Rolls.

Crush-conglomerate. A conglomerate produced by the crushing of certain rocks in the shearing movements following folding.

Crushing rolls. A machine consisting of two heavy rolls between which mineral is crushed. Sometimes the rolls are toothed or ribbed, but for ore their surface is generally smooth.

Crushing strength. The resistance which a rock offers to vertical pressure placed upon it. It is measured by applying graduated pressure to a cube, one inch square, of the rock tested. A crushing strength of 4,000 pounds means that a cubic inch of the. rock. withstands. pressure. to. 4,000 pounds. before. crushing. . The. crushing strength is greater with shorter prisms, and less with longer prisms.

Crush line. In geology, a line along which rocks, under great compression, yield, usually with the production of schitosity.

Crush movement. In geology, compression, thrust, or lateral movement tending to develop shattered zones.

Crush plane. In geology, a plane defining zones of shattering which result from lateral thrust.

Crush zone. In geology, a zone of faulting and brecciation in rocks.

Crystalline aggregate. An aggregate of crystalline grains or fragments, as granite

not showing well-defined crystal forms.

Crystalline limestone. Limestone composed largely or wholly of crystallized material, commonly as the result of metamorphism.

Crystalline rock. A rock composed of closely fitting mineral crystals that have formed in the rock substance, as contrasted with one made up of cemented grains of sand or other material or with a volcanic glass.

Crystalline schists. Rocks that have been entirely or partly recrystallized by metamorphism.

Cubical cleavage. Equally good cleavage in three mutually perpendicular directions.

Culm bank; Culm dump. A heap or pile of waste kept separate from the rock and slate dumps.

Culm bar. A peculiar bar used in grates designed for burning culm or slack coal.

Current meter. 1. An instrument, as a galvanometer, for measuring the strength of an electric current. 2. Any instrument for measuring the velocity force, etc., of currents.

Cushioned hammer. A power-hammer striking a cushioned blow.

Cut holes. The first round of holes fired in a tunnel or shaft. They are so placed as to force out a cone-shaped core in the center of a heading, and relieve the burden on the the second round of shots.

Cut-off. 1. A quarryman's term for the direction along which the granite must be channeled, because it will not split. Same as Hard way. 2. The new and relatively short channel formed when a stream cuts through the neck of an oxbow. 3. The act of shutting off the admission of steam to an engine; also the mechanism for effecting this cut-off at the proper point in the cycle.

Cut-out. A device for cutting out a portion of an electric circuit, generally including a fuse designed to melt when the current exceeds a certain strength. A circuit breaker.

Cutter. (Mt. Pleasant, Tenn.) An opening in limestone, enlarged from cracks as fissures, by solution, which is filled by clay and usually contains valuable quantities of brown phosphate rock.

Cwt. An abbreviation for a hundredweight, or 112 pounds avoirdupois.

Cnanamid. A trade name for a material containing about 50 per cent true cyanamide and 25 per cent calcium hydroxide.

Cyanamide. A white crystalline compound (CH_2N_2 formed by the action of cyanogen chloride on ammonia.

D

Damourite. A hydrous muscovite.

Datum. 1. Any position or element in relation to which others are determined, as datum point; or datum line; datum place. 2. The mean lowwater mark of all tides, assumed as a base of reckoning.

Datum level. The level (usually sea level of nearest considerable body of water) from which altitudes are measured in surveys.

Datum water level. The level at which water is first struck in a shaft.

Dead air. The air of a mine when it contains carbonic-acid gas (black damp), or when ventilation is sluggish.

Dead end (of a pipe). The closed end of a pipe or system of pipes.

Deadfall. A dumping platform at the mouth of a mine.

Deadman. 1. A buried log, or the like, serving as an anchor, as for a guy rope. 2. A wooden block used to guard the mouth of a mine against runaway cars.

Dead weight. The unrelieved weight of anything inert. A heavy or oppressive burden.

Deadwork. Work that is not directly productive, though it may be necessary for exploration and future production. Unfinished work.

Debris. Rock fragments, sand, earth, and sometimes organic matter, in a heterogeneous mass, as at the foot of a cliff. 2. The silt, sand, and gravel that flow from hydraulic mines; called in miner's parlance, tailings, slums, and sometimes slickens.

Declaratory statement. In practical mining operations, a term applied to the statutory certificate of location and is a notice or statement of the location, containing a description of the mining claim, verified by the oath of the locator, performing, when recorded, a permanent function, and is the beginning of the locator's paper title, is the first muniment of such title and is constructive notice to all the world of its contents.

Declination. The angle which the magnetic needle makes with the geographical meridian. It is said to be east or west, according as the north end of the needle points to the east or west of the geographical meridian.

Decrepitation. The breaking up with a crackling noise of mineral substances when exposed to heat.

Deformation of rocks. 1. Restrictedly, distortion of rock masses by pressure, evidenced by foliation, mutual indentation of pebbles in conglomerate, distortion of fossils, stylolites, etc. 2. Any change in the original shape of rock masses. Folding and faulting are common modes of deformation.

Degradation. The general lowering of the surface of the land by erosive processes, especially by the removal of material through erosion and transportation by flowing water.

Dehydrate. To render free from water.

Delay electric blasting-cap.—A detonating device with a delay element between the priming and detonating compostion. It detonates about one or two seconds after the electric current has passed through the bridge. They are made in two kinds—first and second delay—and are used in connection with regular, waterproof or submarine electric blasting-caps for blasting in tunnels, shafts, etc., where it is desirable to have charges fired in succession without the necessity of the blaster returning between shots.

Delay electric-igniter. An electrical device using fuse as the delay element by which it is possible with the use of a blasting cap on each fuse to detonate a number of charges in succession.

Demurrage. A charge for the detention of railway cars over a certain period allowed for loading or unloading.

Densimeter. An apparatus for determining the specific gravity or relative density of a substance.

Density. 1. The ration of the mass of any volume of a substance to the mass of an equal volume of some standard substance. For liquids and solids the standard substance is water. 2. The quality of be-

ing dense, close, or compact. 3. The quantity of electricity per unit of volume at a point in space, or the quantity of electricity per unit of area at a point on a surface.

Denudation. In geology, the same as erosion, although there has been an effort by some to restrict the term to the stripping away of overlying material from some particular rock or surface.

Depletion. The act of emptying, reducing or exhausting, as the depletion of natural resources. In mining, specifically said of ore reserves.

Deposit. The term mineral deposit or ore deposit, is arbitrarily used to designate a natural occurrence of a useful mineral or ore in sufficient extent and degree of concentration to invite exploitation.

Deposition. The process of natural accumulation of rock material, as when thrown or collected in strata by water, wind, or volcanic action: also material thus deposited.

Depreciation. The loss in the volume of physical property due to use, or otherwise, which cannot be made good by current repairs.

Depreciation fund. A fund set aside to replace a piece of depreciable property when it is worn out.

Derivative rocks. Rocks derived by erosion or comminution from existing rocks or rock material, as a sedimentary rock and

Derrick. 1. The framework or tower over a deep drill hole, such as that of an oil well, for supporting the tackle for boring, hoisting or lowering. 2. Any of various hoisting apparatus employing a tackle rigged at the end of a spar or beam.

Derrick car. A car fitted with a derrick or crane.

Derrick crane. A crane in which the top of the post is supported by fixed stays in the rear and the jib is pivoted like the boom of a derrick.

Desmosite. A banded contact rock developed from shales and slates by instrusions of diabase.

Destructional. Pertaining to destruction or shaped by destructive forces, as in geology, a plain which has been formed by erosion.

Detaching hook. A self-acting mechanical contrivance for setting free a winding rope from a cage when the latter is raised beyond a certain point in the headgear; the rope being released, the cage remains suspended in the frame.

Determinative mineralogy. That branch of mineraology which comprises the determination of the nature, composition, and classification of minerals, by means of physical tests, blowpipe or wet analyses.

Detonate. 1. To cause to explode with a sudden loud report. 2. To explode suddenly with a loud report.

Detonating fuse. A fuse consisting of high explosive that fires the charge without the assistance of any other detonator.

Detonating gas. A mixture of two volumes of hydrogen and one volume of oxygen which explodes with a loud report upon ignition.

Detonating powder. Any powder or solid substance, which when heated or struck explodes with violence and a loud report.

Detonating primer. A primer exploded by a fuse, used to fire high explosives.

Detonation. The very sudden change of unstable substances from a solid or liquid to the gaseous state with the evolution of great heat and accompanied by a sudden report.

Detonator. A term used to include blasting caps, or any device used for detonating a high explosive. An exploder, percussion cap, or primer.

Detonator tube. A eudiometer fitted for making explosions.

Detrital rock. A rock made up of the debris of other rock.

Detritus. A general name for incoherent sediments, produced by the wear and tear of rocks through the various geological agencies. The name is from the Latin for "Worn." Rock waste.

Development. A geological term, applied to those progressive changes in fossil genera, and species, which have followed one another during the deposition of the strata of the earth.

Devonian. In the ordinarily accepted classification, the fourth in order of age of the periods comprised in the Paleozoic era, following the Silurian and succeeded by the Carboniferous. Also the system of strata deposited at that time.

Diabase. A basic igneous rock usually occurring in dikes or intrusive sheets, and composed essentially of plagioclase feldspar and augite with small quantities of magnetite and apatite. The plagioclase forms lathsshaped crystals lying in all directions among the darg irregular augite grains, giving rise to the peculiar diabasic or ophitic texture, which is a distinctive feature in the coarser-grained occurrences.

Diagonal stratification. Same as False bedding. Current bedding, and also Cross-bedding.

Diamagnetic. Possessing or pertaining to the property of being repelled by a magnet and of tending to take a position at right angles to the magnetic force.

Diamond drill. A form of rotary rock drill in which the work is done by abrasion instead of percussion, black diamonds (borts) being set in the head of the boring tool. Used in prospecting and development work where a core is desired.

Diatomaceous earth. A friable earthy deposit composed of nearly pure silica and consisting essentially of the frustules of the microscopic plants called diatoms; diatomite. Sometimes wrongly called infusorial earth.

Diesel engine. An internal combustion engine in which only air is drawn in by the suction stroke, and the air is so highly compressed that the heat generated ignites the fuel which is automatically sprayed into the cylinder under high pressure.

Difference of potential. The difference in electrical pressure existing between any two points in an electrical system or between any point of such a system and the earth, as determined by a voltimeter.

Differential pumping engine. A compound direct-acting pumping engine, generally of the horizontal class.

Dike. A long and relatively thin body of igneous rock, which, while in a state of fusion, has entered a fissure in older rocks and has there chilled and solidified.

Diluvian. 1. Sand, gravel, clay, etc., in superficial deposits. According to some authors, alluvum is the effect of the ordinary ,and diluvium of the extraordinary action of water. The latter term is now passing out of use as not precise, and more specific names for the different kinds of material are substituted. 2. A name formerly

applied to the unsorted and sorted deposits of the Glacial period, as contrasted with the later water-sorted alluvium.

Dimension stone. Stone that is quarried or cut in accordance with required dimensions.

Dinky. A small locomtive used to move cars in and about mines and quarries.

Diorite. A granitoid rock composed esentially of hornblende and feldspar which is mostly or wholly plagioclase, with accesory biotite and (or) augite. Minute grains of magnetite and titanite may be visible. Quartz may be present in considerable amount, in which case the rock is called quartz diorite.

Dip. The angle at which beds or strata are inclined from the horizontal, while underlie is the angle formed between a vein and a vertical line. The first is a geologist's term, the second a miner's.

Dip entry. An entry driven down hill so that water will stand at the face. If it is driven directly down a steep dip it becomes a slope.

Dipper dredge. A dredge in which the material excavated is lifted by a single bucket on the end of an arm, in the same manner as in the ordinary steam shovel.

Direct draft. Having a single direct flue; applied to steam boilers.

Direct firing. The cobustion of coal effected by burning directly on a grate.

Direction of strata. The strike, or line of bearing.

Dirt scratcher. A person whose duty it is to take down loose rock, clear away dirt, and perform such other like work as requires no special skill or experience.

Discordance. In geology, a lack of parallelism between contiguous strata. An unconformity.

Disintegration. The breaking asunder and crumbling away of a rock, due to the action of moisture, heat, frost, air, and the internal chemical reaction of the component parts of rocks when acted upon by these surface influences.

Disintegrator. A machine for breaking coal into powder.

Dislocation. A shifting of the relative position of the rock on either side of a crack, or break. It may be up, down, or to one side. Equivalent to slip, slide, fault, throw, heave, upthrow, downthrow, trouble.

Displacement. The displacement of an air compressor is the volume displaced by the net area of the compressor piston.

Disruptive. A term applied to that kind of force exerted by an explosive that tends to shatter the rock into fragments.

Dissection. In geology, the work of erosion in destroying the continuity of a relatively even surface by cutting ravines or valleys into it.

Disturbance. The bending or faulting of a rock or stratum from its original position.

Ditch wiring. The method of connecting electric blasting caps in such a way that the two free ends can be connected at one end of the line of holes.

D-link. A flat iron bar attached to chains, and suspended by a rope from a windlass. It forms a loop in which a man sits when lowered or raised in a shaft or winze.

'Dobie. A term applied to the mud cap or adobe method of secondary blasting.

Dodge crusher. Similar to Blake crusher, except the movable jaw is hinged at the bottom. Therefore the discharge opening is fixed, giving a more uniform product than the Blake with its discharge opening varying every stroke. This type of crusher gives the greatest movement on the largest lump.

Dodge pulverizer. A hexagonal barrel revolving on a horizontal axis, containing perforated die plates and screens. Pulverizing is done by steel balls inside the barrel.

Dolerite. Coarsely crystalline basalt.

Dolomite. 1. A carbonate of calcium and magnesium, (Ca, Mg) CO_3. 2. A term applied to those rocks that approximate the mineral dolomite in composition. Named by Saussure, after Dolomieu, an early French geologist. Also called Magnesian limestone. It occurs in a great many crystalline and noncrystalline forms the same as pure limestone, and among rocks of all geological ages. When the carbonate of magnesia is not present in the above proportion the rock may still be called a magnesian limestone, but not a dolomite, strictly speaking.

Dome. The upper part of a furnace. The vertical steam chamber on top of a boiler.

Donkey. See Barney. Also used synonymously for Donkey engine, Donkey pump, Donkey hoist.

Donkey engine. A small auxiliary engine.

Donkey hoist. An auxiliary hoisting engine operated by steam or compressed air.

Donkey pump. Any of several kinds of combined pump and steam engine. It may be operated independently of the engine: Used to supply water to a boiler, drain sumps, etc.

Dope. An absorbent material; especially in high explosives, the sawdust, infusorial earth, mica, etc., mixed with nitroglycerin as in dynamite.

Dorr agitator. An agitating machine based on the thickener principle. It is essentially a Dorr classifier equipped with a central air lift.

Dorr classifier. A machine to diminish the amount of water required for classification by raking the heavier grains up an inclined plane against a light current of water, which washes away the lighter material. It is of the intermittent type.

Double-acting pump. A pump which discharges at both forward and backward stroke.

Double core-barrel drill. A core drill having an inner tube that is suspended on ball bearings and thus may remain still while the outer tube revolves. It is designed to bring out a core from a delicate material with a minimum of breaking or other damage.

Double load. A charge in a bore hole separated by a quantity of inert material for the purpose of distributing the effect, or for preventing part of the charge blowing out at a seam or fissure, in which case the inert material is placed so as to include the seam.

Double-tape fuse. Fuse of superior quality, or having a heavy and strong covering.

Down holes. Drill holes that incline downward.

Dowse. To use the dipping or divining rod, as in search of water, ore, etc.

Dowser. A divining rod for dowsing; also one who uses a divining rod.

Drag. 1. A wooden or iron bar placed between the spokes of the wheels of trams to check their speed upon an inclined way. 2. An appliance to be attached to the rear of a loaded train of cars to prevent the

cars from running down the incline or grade in case the cable should break. 3. The frictional resistance offered to a current of air in a mine.

Dragbar; Back stay. An iron bar fastened to the back of a skip to prevent the latter running down hill in case the hauling rope breaks.

Drag bolt. A coupling pin.

Drag chain. A chain to make fast a wheel of a vehicle so that the wheel will act as a drag.

Dragline scraper. A type of apparatus for the removal of soil. It consists of one or more buckets or scrapers attached to an endless cable or belt operated by a drum or sprocket wheel.

Dragstaff. A pole projecting backward and downward from a vehicle, to prevent it from running backward.

Drag stone mill. A mill in which ores, etc., are ground by means of a heavy stone dragged around on a circular or annular stone bed.

Drag twist. A spiral hook at the end of a rod, for cleaning bore holes.

Draw bar. 1. A bar used to connect rolling stock, as a bar with a single eye at each end for coupling together a locomotive and its tender. 2. A heavy beam under the body of a railway car and projecting at the end for coupling cars.

Drawhead. The head of a draw bar.

Drawing lift. The lowest lift of a cornish pump, or that lift in which the water rises by suction (atmospheric pressure) to the point where it is forced upward by the plunger.

Drawing small. When a winding rope, from the effects of wear and tear, has become less in diameter or in thickness from that cause, it is said to be "drawing small."

Dredge. A scoop or suction apparatus, operated by power, and usually mounted on a flat-bottomed boat, for clearing out or deepening channels, harbors, etc., by taking up and removing mud or gravel from their bottoms. Extensively used in mining gold-bearing sand and gravel. For this purpose it is equipped with screening apparatus and gold-saving devices. Also called Dredging machine.

Dredge boat. A boat bearing a dredging machine, especially one used in dredging river channels and in mining sand and gravel.

Dredging pump. A pump for drawing up silt, loose sand, etc., as in dredging.

Dredging tube. The large tube of a dredging machine that operates by suction for the removal of mud, sand, etc.

Drift. 1. A horizontal passage underground. A drift follows the vein, as distinguished from a crosscut, which intersects it, or a level or gallery, which may do either. 2. Any rock material, such as bowlders, till, gravel, sand, or clay, transported by a glacier and deposited by or from the ice or by or in water derived from the melting of the ice. Generally used of the glacial deposits of the Pleistocene epoch. Detrital deposits.

Drift-bed. In geology, a layer of drift of sufficient uniformity to be distinguished from associated ones of similar origin; a drift stratum.

Driftbolt. A bolt for securing together successive layers, as of stones in a foundation or of timbers in a grillage.

Drill. 1. A metallic tool for boring in hard material. The ordinary miner's drill is a bar of steel with a chisel-shaped end, and is struck with a hammer. See Rock drill, Diamond drill. 2. To make a hole with a drill or similar tool. 3. See Drilling, as applied to oil and gas wells.

Drill core. A solid, cylindrical core of rock cut out by a diamond or shot drill. It forms a record of the strata through which the drill has passed.

Driller. 1. One who or that which drills. 2. A drilling machine.

Drill extractor. A device for withdrawing the drill bit from wells; drill tongs.

Drilling. A term employed in a general way to denote the different processes employed for the discovery and extraction of petroleum or natural gas. Two general methods of drilling have come to be recognized: (a Percussion systems, which consist of breaking up the ground by means of a sharp pointed instrument of a particular form, which is made to strike the ground in a series of blows; and (b) Rotary systems, which aim at the extraction of a core or permit all the disintegrated material to be washed away. Also commonly used in prospecting for, and in the development of ore or coal lands.

Drilling jig. A portable drilling machine worked by hand.

Drill rod. A vertical rod bearing a drilling tool for boring.

Drip stone. 1. A porous stone, either artificial or natural, for filtering water. 2. Calcium carbonate in the form of stalactites and stalagmites.

Drive. To excavate horizontally, or at an inclination, as in a drift, adit or entry. Distinguished from sinking and raising.

Driving cap. A cap of iron, fitted to the top of a pipe, to receive the blow when driven and thus protect the pipe.

Drop hammer. A hammer for forging, the weight being raised and then released to drop on the metal resting on the die or anvil.

Drum. That part of the winding machinery on which the rope or chain is coiled.

Drum horns. Wrought-iron arms or spokes projecting beyond the surface or periphery of flat-rope drums, between which the ropes coil or lap.

Drum rings. Cast-iron wheels, with projections, to which are bolted the staves or laggings forming the surface for the hoisting cable to wind upon. The outside rings are flanged, to prevent the cable from slipping off the drum.

Dryer. An apparatus for drying minerals. Dryers are of various types as: revolving, cylindrical, zigzag, tower, and cast-iron plates.

Dry method. The method of mixing the raw materials of Portland cement in a dry state.

Dry pan. A circular revolving pan with perforated bottom, in which two large rollers revolve by friction against the pan floor. It is used for grinding dry clays.

Dry sand. 1. Sand prepared for molds by thorough drying and baking. When special cohesion is required (as for cores) other substances, such as flour, molasses, etc., are mixed with it. 2. A stratum of dry sand or sandstone encountered in well drilling. A nonproductive sandstone in oil fields.

Dualin. A variety of dynamite consisting of 4 to 5 parts nitroglycerin, 3 parts sawdust, and 2 parts saltpeter.

Duck's nest. See Springing.

Ductile. Capable of being permanently drawn out or hammered thin.

Dummy. A paper bag filled with sand, clay, etc., for tamping or for separating two charges in a double-loaded bore hole.

Dump cart. A cart or car having a body that can be tilted, or a bottom opening downward, for emptying.

Dump hook. A chain grab hook having a lever attachment for releasing it from the object to which it is connected.

Dump-skip. A skip with an attachment that dumps the load automatically.

Dune. A heap of blown sand.

Duplex breaker. A breaker having more than one crushing chamber.

Duplex wire. Two insulated-copper leading-wires wrapped together with paraffined cotton covering.

Duriron. An acid-resisting alloy used in chemical works and laboratories. It consists of 14 to 14.5 per cent silicon, 0.25 to 0.35 per cent manganese, 0.2 to 0.6 per cent carbon, 0.16 to 0.2 per cent phosphorus, and under 0.05 per cent sulphur, the remainder being iron.

Dust. Earth or other matter in very fine particles, so attenuated that they can be raised and carried by the wind; finely comminuted or powdered matter.

Dust explosion. An explosion of carbonaceous material as coal dust, flour, etc.

Dust firing. The burning of coal dust in the furnace.

Dutch drop. A haulage term used at Anaconda, Mont., for flying switch.

Duty. 1. A measure of the effectiveness of a steam engine, usually expressed in the number of foot-pounds (or kilogram-meters) of useful work obtained from a given quantity of fuel. (Raymond). **2.** (of a Cornish pumping engine). The number of pounds of water raised one foot high with a consumption of 112 lbs. of coal.

Dying out. Applied to veins that gradually get narrower and narrower until they cease entirely.

Dynamic head. That head of fluid which would produce statically the pressure of a moving fluid.

Dynamite. Originally, an explosive made of 75 per cent nitroglycerin absorbed in 25 per cent kieselguhr; now any high explosive containing explosive ingredients and used for blasting purposes. A composition of detonating character containing nitroglycerin. "Detonating character" is used with intention, because nitroglycerin enters into the composition of mixtures which are propellants, and which are not dynamite. There are other compositions of matter containing nitroglycerin which are not dynamite, but we cannot have a dynamite which does not contain nitroglycerin. The strength varies according to the percentage of nitroglycerin contained. Frequently called Giant powder.

Dynamiter. One who uses, or is in favor of using, dynamite or similar explosives for unlawful purposes.

Dynamo. A machine used for converting mechanical energy into electrical energy by magneto-electric induction.

Dyne. In physics, the unit of force in the centimeter-gram-second system, being that force which acting on one gram for one second generates a velocity of one centimeter per second.

E

Earth auger. An earth borer.

Earth borer An auger for boring into the ground. It works in a cylindrical box which retains the cut earth until the tool is withdrawn.

Earth's crust. The external part of the earth, accessible to geological investigation. The use of this term does not necessarily imply that the rest of the earth is not also solid.

Earth-tilting. A slight movement or displacement of the surface of the ground as in some forms of earthquakes.

Easement. An incorporeal right existing distinct from the ownership of the soil, consisting of a liberty, privilege, or use of another's land without profit or compensation; a right of way.

Ebb-and-flow structure. A stratification consisting of horizontally laminated layers, with others obliquely laminated, indicative of alternations of tidal currents during deposition.

Eccentric bit. A modified form of chisel used in drilling, in which one end of the cutting edge is extended further from the center of the bit than the other. The eccentric bit renders under-reaming unnecessary. It is very useful in hard rock.

Eclogite. A more or less schistose metamorphic rock, consisting of a light-green pyroxene (omphacite), actinolite (var. smaragdite) and garnet. Scarcely known in America.

Economizer. An apparatus for utilizing the heat that would otherwise be wasted, as in a system of water tubes in the uptake of a boiler to heat the feed water.

Edge mill. A crushing or grinding mill in which a pair of stones or metal rollers are rolled around at the ends of a horizontal shaft turning about a central vertical axis. Also called Edge runner, and Chaser.

Edge runner. See Chilean mill; Edge mill; Chaser.

Effervesce. To bubble and hiss, as limestone on which acid is poured.

Effusive. In petrology, poured out or erupted on the surface of the earth in a molten state, before solidification; extrusive; said of a certain class of volcanic igneous rocks.

Ehrhardt powder. Any of a series of explosive mixtures containing potassium chlorate, together with tannin, powdered nutgalls, or cream of tartar, and used for blasting, shells, etc.

Elastic limit. That point at which the deformation in the material ceases to be proportional to the stresses.

Electric air-drill. A type of tripod drill operated by compressed air supplied by a portable motor-driven compressor that accompanies the drill.

Electric blasting. The firing of one or more charges electrically, whether electric blasting caps, electric squibs, or other electric igniting or exploding devices are used.

Electric blasting cap. A device for detonating charges of explosives electrically. It consists essentially of a blasting cap, into the charge of which a fine platinum wire is stretched across two protruding copper wires, the whole fastened in place by a composition sulphur plug. The heating of the platinum wire bridge by the electric current ignites the explosive charge in the cap, which in turn detonates the high explosive.

Electric detonator. An electric blasting cap.

Electric drill. A mechanically operated

drill employing neither compressed air nor steam, but driven by electric motor.

Electric exploder. A former designation for Electric blasting cap.

Electric locomotive. A locomotive driven by electricity, either trolley or storage battery type.

Electric squib. A device similar to an electric blasting cap, but containing a gunpowder composition which simply ignites but does not detonate an explosive charge; used for electric firing of blasting powder.

Elutriation. Purification by washing and pouring off the lighter matter suspended in water, leaving the heavier portions behind.

End-bump table. A mechanically operated, sloping table by which heavy and light minerals are separated. The end motion imparted to the table tends to drive all minerals up the slope of the table, but a flow of water carries the quartz and other light minerals down faster than the mechanical motion carries them up. The heavy minerals settle to the bottom and finally reach the upper end and are delivered into a proper receptacle.

Endless-chain haulage. See Endless-rope haulage.

Endless-rope haulage. A haulage system using an endless traction rope or chain for transporting cars, either on surface or underground tramways.

Enhydrous. Containing water; having drops of included fluid; as, enhydrous chalcedony.

Eocene. In the usage of the U. S. Geological Survey, the earliest of the epochs into which the Tertiary period is divided; also the series of strata deposited at that time.

Eozoic. Pre-C a m b r i a n; pre-Paleozoic. Formerly applied to the rocks now included in the Archean and Algonkian systems and the corresponding geologic periods, being intended to supplant Azoic when it was learned that the Azoic rocks contain some fossil remains.

Epidote. A basic orthosilicate of calcium, aluminum, and iron, H_2O. $4CaO.3(Al,Fe)_2O_3.6SiO_2$ (U. S. Geol. Surv.). The name of this mineral is often prefixed to the names of rocks containing it. As a rule, the presence of epidote indicates the advance of alteration.

Erosion. The group of processes whereby earthy or rock material is loosened or dissolved and removed from any part of the earth's surface.

Eruption. In geology, the emission or ejection, at the earth's surface, through a crater, pipe, or fissure, of such material as lava, heated water, gases, mud, stones, and dust; characteristic of volcanoes and geysers and usually more or less sudden, violent, and explosive.

Eurite. Used among the French as a synonym for felsite, but also applied to compact rocks chiefly feldspar and quartz, such as some granulites.

Expansion bit. A drill bit that may be adjusted for holes of various sizes.

Expansion joint. A device used in connecting up long lines of pipe, etc., to permit linear expansion or contraction as the temperature rises or falls.

Expansion loop. Either a bend like the letter U or a coil in a line of pipe to provide for expansion or contr.

Expansion tamping. A term used in quarrying when the drill hole above the powder charge is filled for several inches with hay, tow, or the like, followed by several inches of clay lightly tamped and finally by well-packed stemming.

Explode. To burst or expand violently and noisily, as gunpowder explodes, or as a boiler explodes, or as an explosion of gas, or coal dust.

Exploder. A cap or fulminating cartridge, placed in a charge of gunpowder or other explosive, and exploded by electricity or by a fuse. Also called Detonator.

Explosion. 1. A sudden ignition of a body of fire damp, coal dust, or explosives, as powder, dynamite, etc. 2. The act of exploding; rapid combustion, decompisition, or other similar process resulting in a great and sudden development of gases, and consequent violent increase of pressure, usually accompanied by a loud report. 3. A sudden breaking apart, shattering or bursting in pieces by internal pressure, as that of gas or steam.

Explosion proof. The term "explosion-proof casing or inclosure" means an inclosure that is so constructed and maintained as to prevent the ignition of gas surrounding it by any sparks, flashes, or explosions of gas that may occur within such inclosure.

Explosion-proof motors. The Bureau of Mines has applied the term "explosion proof" to motors constructed so as to prevent the ignition of gas surrounding the motor by any sparks, flashes, or explosions of gas or of gas and coal dust that may occur within the motor casing.

Explosive. Any mixture or chemical compound by whose decomposition or combustion gas is generated with such rapidity that it can be used for blasting or in firearms, for example, gunpowder, dynamite, etc.

Explosive permissible. See Permissible explosive.

Extra dynamite. The present designation of those explosives consisting of nitroglycerin, other explosive ingredients and an active base absorbent. They are more easily affected by water than straight dynamite, but give off less noxious fumes, are less sensitive to blows, and they ignite less easily from sparks.

Extrahazardous. Unusually dangerous: specifically used in insurance in classifying occupational risks, as mining is extrahazardous.

Extralateral right. In the United States Mining law, said of the right which one who locates on the public domain, a claim in which a vein comes to an apex, has to parts of the vein beyond the planes passed through the side lines of his claim, but lying within vertical cross planes passed through the end lines.

Extralite. An explosive mixture of ammonium nitrate, potassum chlorate, and naphthalene.

Extrusive. A term applied to those igneous rocks which have cooled after reaching the surface.

F

Fabian system. See Freefall. May be described as the father of freefall drilling systems, all others having originated from it, although it is not now used in its original form.

Face. In any adit, tunnel, or stope, the end at which work is progressing or was last done. The surface exposed by excava-

tion. The working face, front, or forehead, is the face at the end of the tunnel heading; or at the end of the full-size excavation.

Fahrenheit. Designating a thermometer scale, on which the freezing point of water is 32° and the boiling point is 212°. To convert Fahrenheit readings to centigrade readings, subtract 32° from the former and then divide by 1.8.

Failed hole. A drill hole in which dynamite has been loaded and fails to explode.

Fair-lead. A block, ring, or strip of plank with holes, serving as a guide for the running rigging or for any other rope, to keep it from chafing or fouling.

Fault. In geology, a break in the continuity of a body of rock, attended by a movement on one side or the other of the break so that what were once parts of one continuous rock stratum or vein are now separated. The amount of displacement of the parts may be a few inches or thousands of feet.

Fault rock. The crushed rock due to the friction of the two walls of a fault rubbing against each other.

Fauvelle. A system of drilling, that was invented in 1846 by an Englishman, Beart, and a French engineer, Fauvelle, providing for the continuous removal of the detritus from the well by means of a water flush or current of water. All the waterflush systems now in use are modifications of the Fauvelle system, which has long ceased to be employed in its original form.

Feed. Forward motion imparted to the cutters or drills of rock-drilling or coal-cutting machinery, either hand or automatic.

Feed-water heater. An apparatus for heating water before it is fed to a boiler.

Feldspar. A general name for a group of abundant rock-forming minerals.

Filtering-stone. Any porous stone, such as sandstone through which water is filtered.

Finger grip. An instrument (tool) for recovering from a bore, as of a well, a broken rod, or dropped (lost) tool.

Fireback. The back wall of a furnace or fireplace.

Fire brick. A refractory brick of fire clay or of siliceous material used to line furnaces.

Firing machine. 1. A designation for the electric blasting machine. 2. An apparatus for feeding a boiler furnace with coal. A mechanical stoker.

First aid. The assistance or treatment which should be given an injured person imediately upon injury or as soon thereafter as possible.

Fish-tail bit. A bit usually employed in the rotary system of drilling. It is used for drilling in soft strata, such as sand and clay.

Fissile. Capable of being split as schist, slate and shale.

Fissure. An extensive crack, break, or fracture in the rocks. A mere joint or crack persisting only for a few inches or a few feet is not usually termed a fissure by geologists or miners, although in a strict physical sense it is one.

Flagging a squib. Uncoiling the end of the paper which is impregnated with sulphur or some other combustible substance. Flagging the squib permits more time to elapse from the ignition of the unrolled paper and the firing of the charge of powder.

Flashing point; Flash point. The temperature at which oil, being heated, begins to evolve vapor in such quantity that on the application of a small flame a momentary flash due to the ignition of the vapor occurs.

Flat cut. A manner of placing the bore holes, for the first shot in a tunnel, in which they are started about 2 or 3 feet above the floor and pointed downward so that the bottom of the hole shall be about level with the floor.

Fleet. The movement of a rope sidewise when winding on a drum.

Fleet wheel. A grooved wheel or sheave that serves as a drum and about which one or more coils of a hauling rope pass.

Flocculate. To aggregate in small lumps; said of soils and sediments. A term also used in the flotation process.

Floor. 1. The rock underlying a stratified or nearly horizontal deposit, corresponding to the foot wall of more steeply-dipping deposits. 2. A horizontal, flat ore-body.

Fluke. A rod used for cleaning drill holes before they are charged with powder.

Flume. 1. An inclined channel usually of wood and often supported on a trestle, for conveying water from a distance to be utilized for power, transportation, etc., as in placer mining, logging, etc. 2. A mill tail. 3. A ravine or gorge with a stream running through it. 4. To transport in a flume, as logs. 5. To divert by a flume, as the waters of a stream, in order to lay bare the auriferous sand and gravel forming the bed.

Fluorine minerals. Minerals containing fluorine, such as apatite, amblygonite, chondrodite, cryolite, fluorite, lepidolite, topaz, and others.

Fluorspar; Fluorite. The mineral calcium fluoride, CaF_2. Color commonly purple, green, or white. It is the fourth in the scale of hardness, or next higher than calcite, and may be scratched by a steel point.

Flux. A salt or other mineral, added in smelting to assist fusion, by forming more fusible compounds.

Fold. Rocks or strata which have been bent into domes and basins or rolls. This structure is observed mainly in mountainous regions, and is characteristic of both the altered and unaltered sedimentary rocks.

Foliation. 1. The banding or lamination of metamorphic rocks as distinguished from the stratification of sediments. 2. A crystalline segregation of certain minerals in a rock, in dominant planes, which may be those of stratification (stratification-foliation) of joints (joint-foliation), of shearing (cleavage-foliation), or of fracture under the strain of flexure (faulting-foliation).

Follower. A drill used for making all but the first part of a hole, the latter being made with a drill of larger gauge, known as a starter.

Follow-up tag. The cardboard tag placed in the cartons, boxes, or cases of blasting supplies, used for identifying the date and place of manufacture.

Foot-pound. A unit of energy, or work, being equal to the work done in raising one pound avoirdupois against the force of gravity the height of one foot.

Formation. As defined and used by the

U. S. Geological Sruvey, the ordinary unit of geologic mapping consisting of a large and persistent stratum of some one kind of rock. It is also loosely employed for any local and more or less related group of rocks. In Dana's Geology it is applied to the groups of related strata that were formed in a geological period. Any assemblage of rocks which have some character in common, whether of origin, age or composition. In chronological geology formations constitute as it were the units, and several formations may go to make up a system. The word is often loosely used to indicate anything which has been formed or brought into its present shape.

Fracture. The character or appearance of a freshly broken surface of a rock or mineral. Peculiarities of fracture afford one of the means of distinguishing minerals and rocks from one another.

Fracture cleavage. The capacity to part along parallel planes, usually in intersecting sets, along which there has been either incipient fracturing or actual fracturing followed by cementation or welding. This structure is developed in shearing planes.

France screen. A traveling-belt screen in which the screencloth is mounted on a series of separate pallets, thus avoiding bending the screen as it goes over the pulleys.

Frangibility. The degree of facility with which a rock can be broken, or yields to the hammer.

Free crushing. Crushing under conditions of speed and feed such that there is plenty of room for the fine to drop away from the coarser part and thereby escape further fine crushing.

Free fall. An arrangement by which, in deep boring, the bit is allowed to fall freely to the bottom at each drop or down-stroke.

Free way. A direction of easy splitting in a rock.

Friable. Easy to break, or crumbling naturally.

Friction breccia. Angular material derived from earth-movements which crush and break the rock on the two sides of a fault.

Front. A designation for the mouth or collar of a bore hole.

Fuel economizer. A feed-water heater consisting of pipes around which the gases of combustion from a furnace pass.

Fuel feeder. A contrivance for supplying a furnace with fuel in graduated quantities. A mechanical stoker.

Fuller's earth. A fine earth resembling clay, but lacking plasticity. It is much the same chemically as clay, but has a decidedly higher percentage of water. It is high in magnesia and possesses the property of decolorizing oils and fats by retaining the coloring matter.

Fulminate. 1. An explosive compound of mercury, $HgC_2N_2O_2$, which is employed for the caps or exploders, by means of which charges of gunpowder, dynamite, etc., are fired. 2. To make a loud sudden noise; to detonate; to explode with a violent report.

Fuse. 1. A core of black powder wrapped with hemp or cotton threads or tape, with various waterproofing compounds between each, or on the outside, to provide a uniform burning speed of the powder core for the firing of explosives, either with or without a blasting cap. 2. Any of various devices, as a tube, casing, cord, or the like filled or impregnated with combustible matter, or a kind of detonator, by means of which an explosive charge is ignited. 3. To liquefy by heat; to render fluid. 4. To unite or blend as if belted together. 5. A safety piece in an electric circuit, that fuses when the current is too strong, called aften Safety strip or Safety plug.

Fuse auger. An instrument for removing part of the filling of a fuse, to regulate its time of burning, the depth of the bore being indicated by a scale.

Fuse gage. An instrument for cutting time fuses to length.

Fuse lighter. A device for facilitating the ignition of the powder core of a fuse. One form is in the shape of a carpet tack covered with a powder composition; another form is in the shape of a cord, which when ignited burns and maintains a "coal of fire" in contact with the exposed powder in the fuse.

Fuse plug. 1. A plug fitted to the fuse hole of a shell to hold the fuse. 2. A fusible plug that screws into a receptacle, used as a fuse in electrical wiring. 3. A plug of fusible metal inserted in a steam boiler so as to prevent any danger that might arise from overheating due to low water.

Fusion. 1. Act or operation of melting or rendering liquid by heat. 2. State of being melted or dissolved by heat. 3. Union or blending o fthings as if melted together.

Fuze. Pronounced as though spelled "fuzee." Originally the device used for exploding the charge in a projectiel and later used as a designation for an electric blasting cap. Now known as an electric blasting cap. A variation of Fuse.

G

Gabbro. A finely to coarsely crystalline igneous rock composed mainly of lime-soda feldspar (labradorite or anorthite), pyroxene, and frequently olivine. Magnetite or ilmenite, or both, and apatite are accessory minerals. It is generally dark colored.

Gad. 1. A steel wedge. 2. A small iron punch with a wooden handle used to break up ore. 3. A metal spike. 4. A chisel or pointed or wedge-shaped bar of iron or steel about 6 inches long for breaking or loosening ore. 5. A bar, billet or ingot of metal. 6. To break or loosen with a gad, as rock. 7. A percussion drill; a jumper.

Gadder. A device for supporting a machine drill and permitting a number of parallel holes being driven from one mounting.

Galena limestone. A Silurian formation in Illinois and adjoining states.

Gallery. In mining, a level or drift.

Gang drill. A set of drills in the same machine operated together.

Gangue. The non-metalliferous or non-valuable metalliferous minerals in the ore; veinstone or lode-filling. The mineral associated with the ore in a vein.

Ganister. A highly refractory siliceous sedimentary rock used for furnace linings.

Gantry. A bridge or platform carrying a traveling crane or winch and supported by a pair of towers, trestles, or side frames running on parallel tracks.

Gardner crusher. A swing-hammer crusher, the hammers being that U-shaped pieces hung from trunnions between two disks keyed to a shaft. When revolved, centrifugal force throws the hammers out

against the feed and a heavy anvil inside the crusher housing.

Garnet. A group of silicate minerals including several special with related chemical structure commonly crystallized in dodecahedrons or trapezohedrons of the isometric (cubic) system.

Gas sand. A sandstone containing natural gas.

Gate valve. A valve with a sliding gate; stop valve.

Gathering motor. A light weight type of electric locomotive used to haul loaded cars from the working places to the main haulage road, and to replace them with empties.

Gathering mule. The mule used to collect the loaded cars from the separate working places, and to return empties.

Gel. A form of matter in a colloidal state that does not dissolve but nevertheless remains suspended in a solvent from which it fails to precipitate without the intervention of heat or of an electrolyte.

Gelatin dynamite. An explosive, the composition of which varies between wide limits, depending upon its use. A typical composition is: 62.5 per cent nitroglycerin; 2.5 collodion cotton; 25.5 sodium nitrate; 8.7 meal, and 0.8 soda (Brunswig, p. 300). It is a plastic, water-proof high explosive, of high density, used principally for close work and where it is exposed to water.

Gelignite. The term by which gelatin dynamite is known abroad.

Geode. A hollow nodule or concretion, the cavity of which is lined with crystals.

Geognosy. That part of geology which treats of the materials of the earth and its general interior and exterior constitution; sometimes nearly synonymous with geology.

Geology. The science which treats of the history of the earth and its life, especially as recorded in the rocks. Three principal branches or phases are usually distinguished: 1. Structural, or geotectonic geology, treating of the form, arrangement, and internal structure of the rocks. 2. Dynamic geology, dealing with the causes and processes of geological change. 3. Historical geology, which, aided by other branches, aims to give a chronological account of the events in the earth's history.

Geophone. A device to determine beneath the surface the exact location of sounds transmitted through the ground.

German. A straw filled with gunpowder to act as a fuse in blasting operations.

Giant. A large nozzle used in hydraulic mining.

Giant powder. A form of dynamite consisting of a mixture of nitroglycerin and kieselguhr.

Gin pit. A shallow mine, the hoisting from which is done by a gin.

Gin pole. Any of the three poles of a hoisting gin. A single pole held in position by guys.

Gin tackle. A tackle arranged for use with a gin; especially, a combination of a double with a triple pulley block which multiplies by five the power exerted.

Gin wheel. The cylinder of a gin or winch.

Gipsy winch. A small winch that may be attached to a post, working either by a rotary motion or by the reciprocating action of a handle having a pair of pawls and a ratchet.

Glacial. In geology, pertaining to, characteristic of, produced or deposited by, or derived from a glacier.

Glass rock. A pure cryptocrystalline Trenton limestone in northern Illinois and southern Wisconsin.

Glass sand. An extremely pure silica sand useful for making glass and pottery.

Glaucolite. A variety of wernerite having a blue or green tint.

Glauconite; Greensand. Essentially a hydrous silicate of iron and potassium, but the material is usually a mixture and consequently varies much in composition. The potash ranges from 2.2 to 7.9 per cent.

Glory hole. 1. A large open pit from which mineral is or has been extracted. 2. An opening through which to observe the interior of a furnace.

Glory hole system. A method of mining using a system of haulageways beneath the block of ore, which has had its top surface exposed by the removal of the overburden. Connecting with the haulageways are chutes that extend up to the surface, and are spaced at intervals of 50 ft., or at any other convenient distance. The excavation of the ore begins at the top of the chute, and the broken ore is removed by loading it out from the chutes into cars on the haulage level. The ore block is worked from the top down. The method is similar in principle to underhand stoping. Also called Milling system and Chute system.

Gneiss. A layered crystalline rock with a more or less well-developed cleavage, but without the fissility of schist.

Gondola. 1. A long platform railroad car, either having no sides or very low sides. 2. A large flat-bottomed river-boat of light build.

Gooseneck. A bent pipe or tube having a swivel joint, so that its outer end may be revolved.

Gopher hole. Same as a coyote hole. It is sometimes used as a designation for any horizontally drilled hole, usually on a level with the mine or quarry floor.

Gopher-hole blasting. A term applied in the Middle West and West to a method of blasting rock by means of charges placed in small tunnels driven into the quarry face at floor level. It is known as "tunnel blasting" in the East.

Gophering. Prospecting work confined to digging shallow pits or starting adits. Term used from similarity of this work to the crooked little holes dug in the soil by gophers.

Grab. An instrument for extricating broken boring tools from a bore hole.

Grade. 1. The amount of fall or inclination in ditches, flumes, roads, etc. 2. To prepare a roadway of more uniform slope. 3. A filling made in improving a roadway. (Steel). 4. An ore which carries a great or comparatively small amount of valuable metal is called respectively a high- or low-grade ore. 5. The degree of strength of a high explosive. Those above 40 per cent nitroglycerin are arbitrarily designated as high-grade and those below 40 per cent strength as low-grade dynamites. (Du Pont). 6. In geology, that slope of the bed of a stream, or of a surface over which water flows, upon which the current can just transport its load, without either eroding or depositing. (La Forge).

Grail. Gravel or sand; anything in fine particles.

Granite. A granular igneous rock composed essentially of quartz, orthoclase or microcline, and mica. Commonly a part of the feldspar is plagioclase. The mica may be either biotite or muscovite or both. Hornblende is a common, and augite an uncommon, component. Apatite, zircon, and magnetite are always present, generally as very small individuals. Commercially, almost all compact igneous rocks are called granite as distinguished from slate, sandstone, and marble.

Granular. Composed of approximately equal grains, either crystalline in outline or rounded by attrition; specifically, in igneous rocks, composed of grains of constituent minerals, each of which has been formed in but one definite stage of the crystallization.

Grapnel. 1. An implement for removing the core left by an annular drill in a bore hole, or for recovering tools, fragments, etc., fallen into the hole. 2. A small anchor with four or five flukes or claws; a grappling iron. 3. A heavy tongs used in handling large logs, stones, etc.

Grappling iron. An instrument consisting of several iron or steel claws for grappling and holding fast to something.

Gravel. Small stones and pebbles or a mixture of sand and small stones; more specifically, fragments of rock worn by the action of air and water, larger and coarser than sand.

Gravel mine. A placer mine; a body of sand or gravel containing particles of gold.

Gravel powder. Very coarse gunpowder.

Gravity plane. A tramline laid at such an angle that full skips running down hill will pull up the empties.

Gravity railroad. A railroad in which the cars descend by their own weight; an inclined railroad.

Graystone. A grayish, or greenish, compact rock, composed of feldspar and augite and allied to basalt.

Greensand. Sedimentary deposit consisting, when pure, of grains of glauconite, which have a dark greenish color.

Green sand. A highly siliceous sand containing a little magnesia and alumina, mixed with about one-twelfth its bulk of powdered coal or charcoal, used when dampened for making molds; distinguished from dry sand. An unburned molding sand.

Greensand marl. Sand or marl containing glauconite.

Griffin roller mill. A centrifugal mill, like the Huntington, except there is one roller only.

Grind. 1. To reduce to a powder by friction as in a mill. 2. To polish or sharpen by friction.

Gripe. A strap brake or ribbon brake on hoisting apparatus.

Gripper. A claw of a submarine dredger. (Standard).

Gripping shot. A shot so placed that the point or inner end of the hole is considerably farther from the face of the material to be broken than is the heel or outer end of the hole.

Grizzly. A grating of iron or steel bars for screening minerals.

Gross ton. The long ton of 2240 pounds avoirdupois.

Ground-water level. The level below which the rock and subsoil, down to unknown depths, are full of water.

Grouser. A temporary pile or heavy iron-shod pole driven into the bottom of a stream to hold a drilling or dredging boat or other floating object in position.

Grout. 1. A term applied to the waste material of all sizes obtained in quarrying stone. 2. A coarse kind of plaster or cement, usually studded with small stones after application, sometimes used for coating walls of a building. 3. A thin cement mixture forced into the crevices of a stratum or strata to prevent ground water from seeping or flowing into an excavation. Frequently employed in shaft sinking and bore-hole drilling.

Gudgeon. The bearing of a shaft, especially when made of a separate piece. A metallic journal set into the end of a wooden shaft.

Guhr dynamite. An explosive prepared by usually mixing three parts nitroglycerin and one part kieselguhr. Other proportions may be used.

Guide tube. A tube for grinding a bit or drill.

Gum dynamite. Explosive gelatin.

Gummite. An alteration product of uraninite of doubtful composition. (Dana).

Gun. A bore hole in which the charge of explosive has been fired with no other effect than to blast off a small amount of material at the mouth of the bore hole; also called a Bootleg or "John 'Odges."

Gunpowder. A black or brown explosive substance, consisting of an intimate mechanical mixture of saltpeter, charcoal, and sulphur, used in gunnery and blasting. It consists of 70 to 80 per cent saltpeter, and 10 to 15 per cent of each of the other ingredients.

Gunpowder paper. Paper spread with an explosive compound. It is rolled up for use in loading.

Guy. A guide; a rope, chain, or rod attached to anything to steady it; a rope which holds in place the end of a boom, or spar; a rod or rope attached to the top of a derrick and extending obliquely to the ground where it is fastened.

Gypsum. Hydrous calcium sulphate, $CaSO_4 + 2H_2O$. Contains 32.5 per cent lime, 46.6 per cent sulphur trioxide, and 20.9 per cent water. Alabaster is a fine-grained compact variety, white, shaded, or tinted. Gypsite is an incoherent mass of very small gypsum crystals or particles, and has a soft, earthy appearance; contains various impurities, generally silica and clay. Satin spar is a fine fibrous variety which has a pearly, opalescent appearance. Selenite is a variety which occurs in distinct crystals or in broad folia. Some crystals are 3 or 4 feet long and clear throughout.

Gyratory breaker; Gyratory crusher. A rock crusher built on the principle of the old fashioned coffee mill. It consists of a vertical spindle the foot of which is mounted in an eccentric bearing within a conical shell. The top carries a conical crushing head revolving eccentrically in a conical maw. There are three types of gyratory; those which have the greatest movement on the smallest lump; those that have equal movement for all lumps; those that have greatest movement on the largest lump.

H

Hade. The angle of inclination of a vein measured from the vertical; dip is measured from the horizontal.

Hammerman. One who strikes with a hammer in hand drilling of holes for blasting.

Handspike. 1. A wooden lever for working a capstan or windlass. 2. A bar used as a lever in lifting weights or overcoming resistance; a heaver.

Hangfire. Said of a charge that explodes later than expected. A hangfire rarely occurs with electric firing, but it is not infrequent with blasting cap and fuse.

Hard head. 1. A hard knob or knot formed by extreme cementation of sandstone in certain spots. 2. A large, smooth, rounded stone found especially in coarse gravel. A nigger head.

Hardinge mill. A tube mill made with two conical sections connected by a central very short cylinder. The cone at the feed end is very short so that the large pebbles settle and grind at the large end where the feed is coarse.

Hardness scale. The scale by which the hardness of a mineral is determined as compared with a standard. The Mohs scale is as follows: 1. Talc; 2. Gypsum; 3. Calcite; 4. Fluorite; 5. Apatite; 6. Orthoclase; 7. Quartz; 8. Topaz; 9. Sapphire; 10. Diamond.

Hardpan. A name specially developed in the digging of auriferous placers, and applied to the layers of gravel which are usually present a few feet below the surface and which are cemented by limonite or some similar bond. They are therefore resistant. It is also used to describe bowlder clay, which is likewise difficult to excavate.

Hard-rock phosphate. A term used in Florida to designate a hard, massive, close-textured, homogenous, light-gray phosphate, showing larger or smaller irregular cavities, that are usually lined with secondary mammilliary incrustations of phosphate of lime.

Haulage plant. A mechanical installation for the tramming of rock, operated by ropes, compressed air, or electricity.

Haulageway. The gangway, entry, or tunnel through which loaded or empty mine cars are hauled by animal or mechanical power.

Header. 1. A rock that heads off or delays progress. 2. A blast hole at or above the head.

Headframe. A structure erected over a shaft to carry the sheaves over which the cable runs for hoisting the cage. Called in England, Gallows frame.

Head gate. A water gate or floodgate of any race or sluice. (Standard).

Headgear. 1. That portion of the winding machinery attached to the headframe, or the headframe and its auxiliary machinery. 2. That part of deep-boring apparatus which remains at the surface.

Heat economizer. A device by which the steam in a steam engine or the hot air of an engine is cooled, causing it to impart its heat to a metallic body which stores up the heat and imparts it in turn to the next charge of steam or air, thus reducing the waste of heat; a regenerator.

Heat unit. A unit of quantity of heat; the heat required to raise the unit mass of water through one degree of temperature.

Heel. The mouth or collar of a bore hole.

Heel of a shot. In blasting, the front of a shot, or the face of the shot farthest from the charge.

Hepatin. An amorphous limonite, of a liver-brown color, and containing a small percentage of copper.

Hepatite. A variety of barite: so called from the fetid odor it exhales when heated.

Heterogeneous. Differing in kind; having unlike qualities; possessed of different characteristics; opposed to homogeneous.

High explosives. Explosives which detonate or are composed of ingredients which detonate. In the United States the designation covers explosives like gelatin, dynamite, blasting gelatin, etc., which are stronger and more sudden in their action than gunpowder.

High furnace. The ordinary blast furnace.

High-grade. An arbitrary designation for dynamite of 40 per cent strength or over.

Hinged-hammer crusher. See Williams Hinged-hammer crusher.

Hirst. A bank of sand in or along a river.

Hitcher. The man who runs trams into or out of the cages, gives the signals, and attends at the shaft when men are riding in the cage.

Hitcher-on. The person employed at the bottom of a shaft or slope to put loaded cars on, and take empty cars off the cage.

Hobo connection. Same as Parallel connection, as used in blasting.

Hoggin. A material composed of screenings or siftings of gravel or a mixture of loam, sand, and gravel, used in making filter beds, as a binding material for metal roads, or the like.

Hoisting block. The lower block of a block-and-fall, bearing the hoisting hook.

Hoisting crab. A crab, winch, or windlass for hoisting.

Hole man. One who loads holes with explosives; a charger.

Hole system. A system of contract work underground by which the pointing of the holes and blasting are done by company men and the rest of the work by the miner.

Hollow reamer. A tool for straightening a crooked borehole.

Homogeneous. Of the same kind or nature; consisting of similar parts, or of elements of a like nature; opposed to heterogeneous.

Hook-on. The man who adjusts cables or chains, about objects to be lifted; places hook or crane-block in bucket bails, and hooks of winches to objects to be moved, etc.

Hopper car. A car for coal, gravel, etc., shaped like a hopper, with an opening at the bottom to discharge the contents.

Hornblende. A variety of the mineral amphibole. Color between black and white, through various shades of green, inclining to blackish green; also dark brown; rarely yellow, pink, rose-red. In part a normal metasilicate of calcium and magnesium, $RSiO_3$, usually with iron, also manganese, and thus in general analogous to the pyroxenes. The alkali metals, sodium and potassium, also present, and more commonly so than with pyroxene. The name of the mineral is prefixed to many rock names.

Horn socket. In well boring, an implement to recover lost tools, especially broken drill poles, etc. It consists of a conical socket, the larger end downward, which slides over the broken part, a spring latch gripping it when entered. Frequently a flaring mouthpiece is riveted to the horn socket, making it a bell-mouth socket.

Horse gin. Gearing for hoisting by horse power.

Horsepower. A unit of power numerically equal to a rate of 33,000 foot pounds of work per minute (=550 foot pounds per second) used in stating the power of a steam engine or other prime mover.

Horsepower hour. The work performed, or energy consumed, by working at the rate of one horsepower for one hour. It is equal to 1,980,000 foot pounds.

Horse run. A device by means of which horses draw loaded vehicles up an incline from excavations.

Horse shovel. A road scraper.

Horses' teeth. A quarryman's term for white elongated crystals of feldspar, which gives the granite its porphyritic character.

Hose. A strong flexible pipe made of leather, canvas, rubber, etc., and used for the conveyance of water, or air under pressure, to any particular point.

Humite. A basic fluo-silicate of magnesium.

Humus. A dark brown substance, formed usually in the soil, due to the partial decomposition of vegetal matter; the organic portion of the soil.

Hung shot. A shot which does not explode immediately upon detonation or ignition.

Huntington mill. A mill of the Chilean type operating by the centrifugal force of steel rollers revolving against the inner surface of a heavy horizontal steel ring or die. The rollers are suspended upon rods from horizontal arms by short trunnions allowing a swing of the rod and roller in a direction radial from the central vertical shaft.

Hurdy-gurdy drill (Aust.). A hand auger used for boring holes in coal. (Power)

Hushing. The discovery of veins by the accumulation and sudden discharge of water, which washes away the surface soil and lays bare the rock.

Hydrate.—1. A compound formed by the union of water with some other substance and represented as actually containing water. 2. Less properly, a hydroxide, as calcium hydrate.

Hydrated. Containing water in chemical combination, and hence in a definite proportion in each case, as gypsum which contains 'water of crystalization,' calcium, hydrate, or lime which has absorbed water on slaking, hydrated oxide of iron, or yellow ocher, which can be readily converted into the anhydrous or red oxide by driving off the water by heat.

Hyraulic. 1. Of, or pertaining to fluids in motion; conveying, or acting, by water; operated or moved by means of water, as hydraulic mining. 2. Hardening or setting under water, as hydraulic cement.

Hydraulic cartridge. A device used in mining to split coal, rock, etc., having 8 to 12 small hydraulic rams in the sides of a steel cylinder.

Hydraulic cement. Cement which sets under water. The rocks, which on being calcined and ground very fine yield this cement, must contain in addition to lime certain proportions of alumina, silica and magnescia. A little iron is also usually present.

Hyraulic dredge. A dredge in which the material to be excavated is mixed with water and pumped through a pipe line to the place of deposit.

Hydraulic elevator. An elevator operated by the weight or pressure of water, especially an apparatus used in dredging and hydraulic mining which raises mud and gravel by means of a jet of water under heavy pressure inducing a strong upward current through the pipe.

Hydraulic gradient. A line showing the fall in pressure of water or other liquid in passing through a pipe discharging at one end.

Hydraulic hose. The flexible hose used to direct a stream of water against a wall or face of drift.

Hydraulicity. The property of hardening under water; said of materials for hydraulic cement.

Hydraulic lime. A variety of calcined limestone which, when pulverized, absorbs water without swelling or heating, and affords a paste or cement that hardens under water.

Hydraulic limestone. A limestone which contains some silica and alumina, and which yields a quicklime that will set or form a firm, strong mass under water, as in hydraulic cements.

Hydrostatic pressure. The pressure exerted by a liquid, as water, at rest.

I

Ice bowlder. A bowlder transported and deposited through glacial action.

Iceland spar. Transparent calcite, which, owing to its strong double refraction, is largely used for optical purposes. Also called Iceland crystal.

Idler. A sheave or pulley running loose on a shaft to guide or support a rope.

Idle wheel. A pulley to guide a driving belt, to increase its tension, or to increase its arc of contact on one of the working pulleys.

Igneo (Sp.). Formed by the joint action of fire and water. Thus ashes thrown from a vocano into water and there deposited in a stratified form might properly be said to be of igneo-aqueous origin.

Igneous. In petrology, formed by solidification from a molten state; said of the rocks of one of the two great classes into which all rocks are divided, and contrasted with Sedimentary.

Igniter. A metal case containing an ordinary fuse at one end with a number of instantaneous fuses branching out from the other end and leading to as many holes to ignite blasting charges.

Ignition charge. A small charge of black or other easily ignited powder, used with the main charge of smokeless or other slow-igniting powder to receive ignition from the primer, thus expediting the main charge.

Impact screen. A type in which the screen moves with the load of material, bringing up against a stop so as to throw the material forward on it.

Impalpable. Extremely fine, so that no grit can be perceived by touch.

Inches of pressure. The height in inches of a column (1) of water, or (2) of mercury, as a measure of hydrostatic pressure.

Inch-pound. A unit of work, being the work done by raising one pound through an inch.

Indicated horsepower. That horsepower which is calculated from indicator-diagrams, as distinguished both from that which is measured by a dynamoter and from nominal horsepower.

Indoor catches. Strong beams in a Cornish pump, to catch the walking beam in case of accident and prevent damage to the engine itself.

Indoor stroke. That stroke of a Cornish pump which lifts the water at the bottom of drawing lift.

Indurated. Hardened; applied to rocks hardened by heat, pressure, or the addition of some ingredient not commonly contained in the rock referred to, as, marls indurated by calcium carbonate.

Indurated talc. An impure, hard, slaty variety of talc.

Infusorial earth; Diatomaceous earth; Tripolite. An earthy substance or soft rock composed of the siliceous skeletons of small aquatic plants called diatoms. (A former and common, but incorrect usage. Properly Diatomaceous earth.) Useful as an absorbent of nitroglycerin. Called also Infusorial silica and Fossil flour, and in special forms Rottenstone and Electro-silicon; Kieselguhr.

Inhaler. Something from or through which one inhales; specifically, an appliance or apparatus of different forms and uses as, for taking the chill from the air before it reaches the lungs; for filtering out iron-dust or other injurious substances from the air breathed through it; for administering medicines by inhalation or, for supplying fresh air to a diver or miner.

Injector. A device for injecting feed water into a steam boier by the direct action of live steam.

Inside slope. A slope on which coal is raised from a lower to a higher entry, but not to the surface. (Steel)

In situ. In its natural position or place; said specifically, in geology, of a rock, soil, or fossil, when in the situation in which it was originally formed or deposited.

Inspector. One employed to make examinations of and to report upon mines and surface plants relative to compliance with mining laws, rules and regulations, safety methods, etc. State inspectors have authority to enforce State laws regulating the working of the mines.

Inspirator. A kind of injector for forcing water by steam.

Internal-combustion. Designating or pertaining to any engine in which the heat or pressure energy necessary to produce motion is developed in the engine cylinder, as by the explosion of gas.

Interrupter. In electricity, a device for rapidly and frequently breaking and making an electric circuit, as in an induction coil.

Intersecting vein. A vein or lode which cuts across one of earlier formation.

Interstice. An opening in anything or between things; especially, a narrow space between the parts of a body or things close together; a crack; crevice; chink; cranny.

Intrusion. In geology, a mass of igneous rock which, while molten, was forced into or between other rocks.

Ion. One of the substances which appears at the respective poles when a body is subject to electrolysis, that one appearing at the anode being called the anion, the other the cathion.

Irruption. In geology, the movement of molten rock from a magmatic reservoir to the place where it solidifies; if the molten rock reaches the surface the process becomes eruption, but that term commonly includes other phenomena as well.

Irruptive rock. An igneous rock which was forced into or invaded other rocks as molten magma. An intrusive rock. The distinction between irruptive and eruptive is often disregarded.

Itabirite. A metamorphic rock, first described from Brazil, of schistose structure and composed essentially of quartz grains and scales of specular hematite. Some muscovite is also present.

Itacolumite; Flexible sandstone. A variety of metamorphosed sandstone, slabs of which will bend noticeably without breaking.

J

Jackhammer. A nonrecriprocating or hammer type of rock drill worked without a tripod and provided with an automatic rotating device. It uses hollow steel through which the exhaust air passes and blows the cuttings from the drill hole.

Jack-heat pit. A small shaft sunk within a mine. A winze.

Jack-head pump. A subordinate pump in the bottom of a shaft, worked by an attachment to the main pump rod.

Jackshaft. 1. An intermediate shaft. See Jack pit. A winze. 2. A column or bar held in place by screw jacks to support or steady a rock drill.

Jacobsite. A deep black, magnetic mineral.

Jamb. 1. A vein or bed of earth or stone, which prevents the miners from following a vein of ore; a large block. 2. A projecting columnar part or mass of masonry; a pillar as of ore.

Jap. See Rock drill.

Jar. To drill by impact, as a rock; to use a drill jar upon.

Jars. In well drilling, a connection between the sinker bar and the poles or cables, made in the form of two links, that slide on each other from 6 to 36 inches. The jars permit the tools to fall on the down stroke, but on the up stroke jar them, or give them a sharp pull, tending to loosen them from any crevices or cavings that may hold them; a drill jar.

Jaw crusher. A machine in which rock is broken by the forcing together of iron jaws.

Jeffrey swing-hammer crusher. A crusher enclosed in an iron casing in which a revolving shaft carries swinging arms having a free arc movement of 1,200. The rotation of the driving shaft causes the arms to swing out and strike the coal, ore, or other material, which, when sufficiently fine, passes through the grated bottom.

Jet pump. A pump which moves fluid by bringing it in contact with a rapidly moving stream of a fluid, of the same or different kind, the motion being imparted through friction. Injectors and aspirators are pumps of this type.

Jim crow. 1. A machine for bending or straightening rails. 2. A crowbar with one end clawed like a hammer.

Jinny. A stationary engine for hauling on a jinny road, when not operated by gravity. A jinny road.

Jinny road. A gravity plane underground.

K

Keeps; Keps. Wings, catches, or rests, to hold the cage when it is brought to rest at the top, bottom, or at an intermediate

landing. Also called Shuts, Fans, Chairs, Dogs.

Keg. A cylindrical container made of steel or some other substance, which contains 25 pounds of blasting powder or gunpowder. Any small cask or barrel having a capacity of 5 to 10 gallons.

Kent roller mill. A revolving steel ring with three rolls pressing against its innner face. The rolls are supported on springs, and the rings support the roll, so that there is some freedom of motion. The material to be crushed is held against the ring by centrifugal force.

Kidneys. 1. Bowlders of phosphate rock. **2.** A term applied by miners to a mineral zone which narrows down until very thin and then suddenly expands and again suddenly contracts.

Kieselguhr. German name for diatomaceous earth, and more or less current in English. Used as an absorbent for nitroglycerin in dynamite. It is an inert substance or passive base, whose only value lies in its capacity to absorb about three times its weight in nitroglycerin.

Kiln. A furnace for the calcination of coarsely broken ore or stone; also an oven for drying, charring, etc. (Raymond)

Kilnhole. The mouth or opening of an oven or kiln.

Kinkead mill. A pan mill with a convex conical bottom on which a muller, having two surfaces of different inclinations, grind. The machine acts on the gyratory principle as regards crushing between the surfaces.

Knox hole. A circular drill hole with two opposite vertical grooves which direct the explosive power of the blast.

Knox system. A system of separating masses of rock by blasting with black blasting powder in reamed drill holes, a considerable air space being left between the charge and the stemming.

Koepe system. A system of hoisting without using drums, the rope being endless and passing over pulleys instead of around a drum.

Krupp ball mill. An ore pulverizer in which the grinding is done by chilled-iron or steel balls of various sizes moving against each other and the die ring, composed of five perforated spiral plates, each of which overlaps the next. The plates form steps which give the balls a drop from one plane to the next, and in addition, give space through which oversize is returned. Outside the die plate is a coarse perforated screen to take the chief wear, while outside that is fine gauze screens. The fines discharge through these into the housing inside which the screens revolve and which has a hopper bottom.

Kutter's formula. A formula for estimating the flow of water in rivers and canals, and sometimes modified for estimating the flow through long pipes with low velocity and entrance head.

L

Labradorite. A lime-soda feldspar.

Ladder. The arm which carries the tumblers and bucket line of a dredge.

Ladder dredge. A dredge having buckets carried on a ladder chain.

Lafayette formation. A fluvioglacial deposit of reddish siliceous sand, from 40 to 200 feet thick, made in the Pleistocene during the first glacial retreat, over the Mississippi Valley to the Gulf, and along the Atlantic coast from Maryland to South Carolina. Formerly called Orange sand and Appomattox formation.

Lagging. 1. Planks, slabs, or small timbers placed over the caps or behind the posts of the timbering, not to carry the main weight, but to form a ceiling or a wall, preventing fragments of rock from falling through. **2.** Heavy planks or timbers used to support the roof of a mine, or for floors of working places, and for the accumulation of rock and earth in a stope.

Lander's crook. A hook or tongs for upsetting the bucket of hoisted rock.

Land fall. A land slide or land slip.

Landing. 1. A level stage for loading or unloading a cage or skip. **2.** The top or bottom of a slope, shaft, or inclined plane.

Land pebbles. A Florida term for certain phosphatic pebbles, as distinguished from river-pebble phosphates.

Land plaster. Any earthy or rock gypsum ground fine and used as a fertilizer.

Land rock. See Phosphate rock; also called Land pebbles.

Lane mill. A low-speed edge-roller mill for fine crushing and amalgamating gold ore crushed by rolls and stamps. Similar to the Chilean mill.

Lang lay rope. A rope in which the wires in each strand are twisted in the same direction as the strands in the rope.

Lap. One coil of rope upon a drum or pulley.

Lapis ollaris. Soapstone, or talc, a hydrated silicate of magnesium.

Lapweld. To weld by overlapping the joints.

Latite. A name suggested for the rocks that are between the trachytes and andesites.

Latrines. Water-closets either fixed or of a portable nature. The latter are often maintained underground for use of miners.

Launder. A trough, channel, or gutter, by which water is conveyed; specifically in mining, a chute or trough for conveying powdered ore, or for carrying water to or from the crushing apparatus.

Laundry box. The box at the surface receiving the water pumped up from below.

Laurentian. According to the U. S. Geological Survey, the younger of the two series of rocks comprised in the Archean system, consisting of igneous rocks which in general underlie, but are intruded into and therefore younger than the rocks of the Keewatin series. Also the corresponding geologic epoch.

Lava. A general name for the molten outpourings of volcanoes. Fluid rock as that which issues from a volcano or a fissure in the earth's surface; also the same material solidified by cooling. It is commonly regarded as a molten rock, but more exactly it is mineral matter dissolved in mineral matter, the solution taking place at high temperatures only.

Law of superposition. The law that underlying strata must be older than overlying strata where there has been neither inversion nor overthrust. Upon this law all geological chronology is based.

Lay. The direction, or length, of twist of the wires and strands in a rope.

Leach. To wash or drain by percolation. To dissolve minerals or metals out of the

ore, as by the use of cyanide or chlorine solutions, acids, or water.

Leach hole. A crevice created in land or rock by the action of leaching or constant filtration; a hole or outlet formed in land by the process of percolation.

Ledge. 1. In mining, ledge is a common name in the Cordilleran region for the lode or for any outcrop supposed to be that of a mineral deposit or vein. It is frequently used to designate a quartz vein (Century). A lode; a limited mass of rock bearing valuable mineral. 2. The term ledge is ordinarily applied to several beds of rock occurring in a quarry. In some instances, however, the term is applied to a single bed.

Ledger. (Eng.). Applied to the lower side of a vein.

Ledge rock. The true bedrock; distinguished from bowlders or rock that has been moved.

Lengthening rod. A screwed extension rod for prolonging a boring auger or bit.

Length of shot. The depth of the hole in which the powder is placed, or the size of the block to be loosened by a single blast measured parallel with the hole.

Levigation. A rubbing down to a powder. Levigation is distinguished from trituration by being done with water, while the latter is the dry method.

Lewis hole. A series of two or more holes drilled as closely together as possible, but then connected by knocking out the thin partition between them, forming thus one wide hole, having its greatest diameter in a plane with the desired rift. Blasts from such holes are wedgelike in their action, and by means of them larger and better-shaped blocks can be taken out than would otherwise be possible.

Lift. 1. The vertical height traveled by a cage in a shaft. 2. The lift of a pump is the vertical distance from the level of the water in the sump to the point of discharge. 3. The distance between the first level and the surface, or between any two levels. 4. A certain thickness worked in one operation. 5. The plane approximately parallel with the floor of the quarry, along which the stone is usually split in quarrying.

Lift pump. A pump for lifting to its own level, as distinguished from a force pump. A suction pump.

Lignite. A brownish-black coal in which the alteration of vegetal material has proceeded further than in peat but not so far as sub-bituminous coal.

Lime. An alkaline earth consisting of the oxide of calcium. Artificially made by calcining or burning limestone or marble. Lime made from dolomitic limestone contains a considerable percentage of magnesia, and is slower setting.

Lime burner. One who burns limstone, etc., to make lime.

Lime cartridge. A charge or measured quantity of compressed dry caustic lime made up into a cartridge and used instead of gunpowder for breaking down coal. Water is applied to the cartridge, and the expansion breaks down the coal without producing a flame.

Lime catcher. A filtering apparatus for extracting calcium salts from the feed water of a steam boiler, thus preventing the deposit of scale in the boiler.

Lime kiln. A kiln or furnace in which limestone or shells are burned and reduced to lime.

Lime powder. Air-slaked lime.

Lime rock. Any rock or stratum in which limestone is a prominent ingredient. Limestone.

Limestone. The general name for sedimentary rocks composed essentially of calcium carbonate.

Limurite. A name for a rock consisting of axinite, pyroxene, amphibole, quartz, titanite, calcite, pyrite, and pyrrhotite. It occurs on the contact of granite and limestone.

Lip. The digging edge of a dredge bucket.

Lithographic stone. A fine-grained homogeneous limestone suitable for etching.

Live load. In mechanics, a load that is variable, in distinction to a constant load.

Live lode. A lode containing valuable minerals.

Load-out. To load coal or rock that is to be taken out of the mine. (Steel)

Liver rock. A variety of sandstone which breaks or cuts as readily in one direction as in another.

Living rock. Rock in its original or native state or location; rock not quarried.

Little giant. A jointed iron nozzle used in hydraulic mining.

Littoral. Of or pertaining to a shore. A coastal region.

Littoral rocks. Rocks composed of coarse material deposited within the limits of the litoral zone, and so subjected to the winds and tides.

Little Jap. See Rock drill.

Loadstone; Lodestone. A piece of magnetite possessing polarity like a magnetic needle. Also called Loadstar, Lodestar.

Locked-wire rope. A rope with a smooth cylindrical surface, the outer wires of which are drawn to such shape that each one interlocks with the other and the wires are disposed in concentric layers about a wire core instead of in strands. Particularly adapted for haulage and rope-transmission purposes.

Lodestone. 1. Magnetic iron ore. See Loadstone. 2. Stone found in veins or lodes.

Log washer. A slightly slanting trough in which revolves a thick shaft or log, carrying blades obliquely set to the axis. Ore is fed in at the lower end, water at the upper. The blades slowly convey the lumps of ore upward against the current while any adhering clay is gradually disintegrated and floated out the lower end.

Long ton. A ton of 2,240 avoirdupois pounds.

Low explosives. A term sometimes used to designate explosives that do not detonate, as blasting powder, in distinction to high explosives, such as dynamite.

Low-freezing dynamite. A dynamite so made that its freezing point is below that of such dynamites as contain only nitroglycerin and an active base and which have a normal freezing point of about 45° F. Low-freezing dynamites do not freeze until temperatures below 32° F. are reached, and even then only after prolonged exposure.

Low-grade. An arbitrary designation of dynamites of less strength than 40 per cent.

Low powders. Explosives containing a small proportion of nitroglycerin and a base similar to blasting powder. Intermediate

between blasting powder and dynamite in action.

Lyddite. A high explosive, chiefly picric acid, used as a shell explosive in the British service.

M

Machine Whim. A winding drum operated by a steam engine.

Magma. In petrology, liquid molten rock; the molten material from which igneous rocks are formed by solidification. An original, parent magma may break up into several derived ones.

Magnesia. Magnesium oxide, MgO. A light, earthy, white substance, obtained by heating the hydroxide or carbonate, or by burning magnesium.

Magnesite. Magnesium carbonate, $MgCO_3$. Crystals rare, usually rhombohedral, also prismatic. Commonly massive; granular, cleavable to very compact; earthy. Color white, yellowish, or grayish-white, brown. Transparent to opaque.

Magnesium. A silver-white metallic element, malleable, ductile and light. Symbol, Mg; atomic weight 24.32; specific gravity, 1.74 (Webster). Used chiefly in the form of ribbon or powder to produce a brilliant light by its combustion, as in signaling, photography, or pyrotechny.

Magnetic separator. A device in which a powerful magnet separates magnetic iron ore from sand or stone.

Main-and-tail-rope haulage. A system of haulage whereby a set of skips connect two ropes, one known as the main, the other as the tail rope. The main rope hauls the full skip out, while the tail rope draws the empties into the mine.

Main bottom. Hard rock below alluvial deposits.

Malchite. A variety of diorite dike that has, in a groundmass of quartz, feldspar, and hornblende, phenocrysts of plagioclase, hornblende, and biotite.

Malingering. A practice indulged in by employee, injured by accident, in order that he may collect accident insurance or other compensation, and at the same time avoid work.

Malthacite. A variety of fuller's earth.

Mammillary; Mammilated. In mineralogy, forming smoothy rounded masses resembling breasts or portions of spheres; said of the shape of some mineral aggregates, as malachite or limonite; similar to but on a larger scale than botryoidal.

Man cage. A special cage for raising and lowering men in a mine shaft.

Man Car. A kind of car for transporting miners up and down the steeply inclined shafts of some mines as at Lake Superior.

Manganese. A hard, brittle, metallic element having a grayish-white color tinged with red and rusting like iron. Not magnetic. Symbol Mn; atomic weight, 54.93; specific gravity, 8.0. The black oxid, pyrolusite, the gray oxide, manganite, and the earthy oxide, wad, are used in the arts. Manganese is used extensively in hardening steel.

Manganese steel. Steel containing about twelve per cent of manganese. A nonfissile alloy that exceeds all other known materials in its combination of hardness and ductility: used chiefly where resistance to abrasion is required, as in crushing and dredging machinery, and in some car wheels.

Man rope. A winding rope used exclusively for lowering and raising men and animals when tacklers and swinging bonts were used and cages were unknown.

Marathon mill. A form of tube mill used in the cement industry, in which the pulverizing is done by long pieces of hardened steel shafting.

Marble. In lithology, a metamorphosed and recrystallized limestone. In the trade, the name is applied to any limestone that will take a polish.

Marcus. A patented shaker screen with a non-harmonic or quick-return motion.

Marcy mill. A ball mill in which a vertical diaphragm is placed about 1 foot from the discharge end. Between this perforated diaphragm and the end of the tube there are arranged screens for sizing the material, oversize being returned for further grinding while undersize is discharged.

Mark. 1. A band of hemp, etc., wrapped around a winding rope to indicate to the engineer the position of the cage in the shaft. 2. The chalk mark made at the working faces, etc., by a fireboss as an indication that he has made an examination of that place.

Marl. A calcareous clay, or intimate mixture of clay and particles of calcite or dolomite, usually fragments of shells. Marl in America is chiefly applied to incoherent sands, but abroad compact, impure limestones are also called marls.

Marmarosis. The general name for the process of crystallization of limestones to marble, whether by contact or regional metamorphism. It was coined by Geikie from the Latin for marble.

Massive. 1. In petrology, (a) of homogeneous structure, without strafication, flowbanding, foliation, schistocity, and the like; said of the structure of some rocks: often, but incorrectly used as synonymous with igneous and eruptive. (b) Occurring in thick beds, free from minor joints and lamination: said of some stratified rocks. 2. In mineralogy, without definite crystalline structure; amorphous.

Mast. The upright pole of a crane or derrick.

Match. 1. A charge of gunpowder put into a paper several inches long, and used for igniting explosives. 2. The touch end of a squib.

Maxton screen. A screening machine of the trommel class, rotating on rollers that support the tube. There are radial elevating ribs, to prevent wear of screen cloth and to elevate the oversize. Unscreened material is delivered on the inside screen surface, undersize passing through and oversize being elevated and discharged into a separate launder.

Mechanical efficiency. Mechanical efficiency of an air compressor is the ratio of the air-indicated horsepower to the steam-indicated horsepower in the case of a steam-driven, and to the brake horsepower in the case of a power-driven machine.

Mediosilicic. In petrology, containing between 50 and 60 per cent silica: said of some igneous rocks; same as Intermediate.

Melinite. A high explosive similar to Lyddite, said to be chiefly picric acid.

Melting point. The degree of temperature at which a solid substance melts or fuses.

Mesh. 1. One of the openings or spaces in a screen. The value of the mesh is usually given as the number of openings

per linear inch. This gives no recognition to the diameter of the wire, so that the mesh number does not always have a definite relation to the size of the hole. 2. Engagement, or working contact, of the teeth of wheels or of a wheel and rack.

Mesozoic. One of the grand divisions or eras of geologic time, following the Paleozoic and succeeded by the Cenozoic era, comprising the Triassic, Jurassic, and Cretaceous periods. Also the group of strata formed during that era.

Metaled. 1. Surface with stone; macadamized: said of an ordinary road. 2. Stone ballasted: said of a railway.

Metamorphism. In geology, any change in the texture or composition of a rock, after its induration or solidification, produced by exterior agencies, especially by deformation and by rise of temperature. The processes and results of cementation and of weathering are not ordinarily included. The most important agents are heat, moisture and pressure.

Meteoric stone. A meteorite, especially one of a stony composition or appearance.

Meteorite. A stony, or metallic, body that has fallen to the earth from outer space.

Mica. A hydrous silicate having a very fine basal cleavage that renders it capable of being split into thin, tough, transparent plates. The most common varieties are muscovite and biotite.

Mica powder. A dynamite in which the dope consists of fine scales of mica.

Mica schist. A foliated, crystalline metamorphic rock composed of alternate layers of quartz and mica in various proportions, the typical one being about two-thirds quartz to one-third mica; although the proportion of the latter generally appears greater than it is, because the rock splits along the mica folia, thus showing the mica along on the flat surfaces. The true compostion may be seen by looking at the squarely broken edges.

Millstone. A hard tough stone used for grinding cereals, cement rocks, and other materials. Usually a coarse-grained sandstone or fine quartz-conglomerate.

Mine locomotive. A low, heavy, haulage engine, designed for underground operation; usually propolled by erectricity, gasoline, or compressed air.

Mineral belt. The strip, or zone, of mineralized territory in a given formation or district.

Miners' inch. The miner's inch of water does not represent a fixed and definite quantity, being measured generally by the arbitrary standard of the various ditch companies. Generally, however, it is accepted to mean the quantity of water that will escape from an aperture one inch square through a two-inch plank, with a steady flow of water standing six inches above the top of the escape aperture, the quantity so discharged amounting to 2274 cubic feet in twenty-four hours. Inasmuch as the miner's inch is a local term "The flow of the water shall be expressed in cubic feet per second, and where it is desirable, for local reasons, to use the term 'miner's inch' it shall represent a flow of 1½ cubic feet per minute.

Miners' needle. A long, slender, tapering, metal rod left in a hole when tamping and afterwards withdrawn, to provide a passage, to the blasting charge, for the squib.

Miocene. The third of the four epochs into which the Tertiary period is divided. Also the series of strata deposited during that epoch.

Miser. A tubular well-boring bit having a valve at the bottom, and a screw for forcing the earth upward. Also spelled Mizer.

Misfire. The failure of a blasting charge to explode when expected. In electric firing, usually due to broken circuit or insufficient current. If the electric blasting cap fires without exploding the charge, it is usually due to misplaced detonator or the charge has been affected by storage in a wet place. Misfires with fuse and blasting-caps are generally due to the fuse going out or to the failure of the fuse to ignite the blasting-cap. Failure of the blasting cap to detonate the dynamite, when it is fired, is usually due to its having been affected by dampness.

Misfire hole; Missed hole. A drill hole containing an explosive charge that has failed to explode.

Modulus of elasticity. A number determining the extension or change of form (strain) of a body under the influence of a stretching or distorting force (stress), and, in the case of a body whose dimensions are all unity, equal to the ratio of the strain to the stress.

Modulus of rupture. The measure of the force which must be applied longitudinally in order to produce rupture.

Monitor. In hydraulic mining, a contrivance consisting of nozzle and holder, whereby the direction of a stream can be readily changed.

Monolith. A single stone or block of stone, especially one of large size, shaped into a pillar, statue, or monument.

Montmartrite. A variety of gypsum, containing calcium carbonate.

Mud cap. A charge of dynamite, or other high explosive, fired in contact with the surface of a rock after being covered with a quantity of wet mud, wet earth, or sand, no bore hole being used. The slight confinement given the dynamite by the mud or other material permits part of the energy of the dynamite being transmitted to the rock in the form of a blow. A mud cap may be placed on top or to one side, or even under a rock, if supported, with equal effect. Also called Adobe, 'Dobie, and Sandblast.

Mudstone. A fine, more or less sandy, argillaceous rock, having no fissile character, and somewhat harder than clay.

Mule. 1. A small car, or truck, attached to a rope and used to push cars up a slope or inclined plane. 2. An extra man who helps push the loaded cars out in case of up-grade, etc.

Mule skinner. A mule driver.

Multiple-bench quarrying. The method of quarrying a rock ledge in a series of successive benches or steps.

Multiple series; Parallel series. A method of wiring a large group of blasting charges by connecting small groups in series and connecting these series in parallel.

Mushroom stone. A fossil resembling a mushroom.

N

Needle. A piece of copper or brass about ½-inch in diameter and 3 or 4 feet long, pointed at one end, and turned into

a handle at the other, tapering from the handle to the point. It is thrust into a charge of blasting powder in a bore hole, and while in this position the bore hole is tamped solid, preferably with moist clay. The needle is then withdrawn carefully, leaving a straight passageway through the tamping for the miner's squib to shoot or fire the charge.

Needle valve. A valve provided with a long tapering point in place of the ordinary valve disk. The tapering point permits fine graduation of the opening. At times called a Needlepoint valve.

Neocene. The later of the two epochs into which the Tertiary period was formerly divided and at one time used by many geologists. Also the series of strata deposited during that epoch. It is no longer used.

Neogene. The later of the two periods into which the Cenozoic era is divided in the classification adopted by the International Geological Congress and used by many European geologists. Also the system of strata deposited during that period. It comprises the Miocene, Pliocene, Pleistocene, and Holocene or Recent epochs.

Neolite. A silky, fibrous, stellated, green, hydrous, magnesium-aluminum silicate.

Neolote. A name used by Clarence King for an order of volcanic rocks embracing the rhyolites and basalts with which, according to the succession formulated by von Richthofen, eruptive activity terminates in any given area.

Neozoic. Pertaining to or designating the entire period from the end of the Mesozoic to the present time.

Neptune powder. An explosive resembling dynamite No. 2, and consisting of nitroglycerin with a more or less explosive dope.

Nest. A small isolated mass of any ore or mineral within a rock.

Newaygo screen. A slanting screen down which the material to be screened passes. The screen is kept in vibration by the impact of a large number of small hammers.

Niggerhead. 1. A bowlder or rounded stone. 2. A black nodule found in granite. 3. Slaty rock occurring with sandstone. 4. A hard, round piece of rock, sometimes found in coal seams. 5. A slip pulley on a winch. The rigger takes about six turns of rope about the pulley, and by varying tension on rope which he holds, can vary speed of hoist on lowering object with engine running.

Nipper. An errand boy, particularly one who carries steel, bits, etc., to be sharpened.

Nitro. A corrupted abbreviation for nitroglycerin or dynamite.

Nitrocellulose. A term used to include the various nitrates of cellulose, such as guncotton, nitroligníne, nitrocotton, nitrojute, etc. The most common of these is nitrocotton.

Nitrocotton. A chemical combination of ordinary cotton fiber with nitric acid. It is explosive, highly inflammable and in certain degrees of nitration, soluble in nitroglycerin.

Nitrogelatin. Same as Gelatin dynamite.

Nitroglycerin. The product of the action of nitric acid and sulphuric acid on glycerin. It is not properly a nitro compound as the name implies but is a nitric ester of glycerin. It is an oily substance about one and one-half times as heavy as water (Sp. gr. 1.6), is almost insoluble in water, and is used as a principal or active ingredient in dynamite, gelatin dynamite, etc. It is not used commercially in the form of a liquid, except for 'shooting' oil wells.

Nodule. A small roundish lump of some mineral or earth, as a nodule of ironstone.

Nominal horsepower. A term used by some engine makers to express certain measurements of cylinder.

Norm. A theoretical, and in part arbitrary, mineral composition of a rock, calculated, in accordance with certain rules, from the chemical analysis, for the purpose of assigning the rock its place in the norm system of rock classification. The norm rarely coincides with the real mineral composition, or mode, of a rock.

Novaculite. An excessively fine-grained, quartzose rock supposed to be a consolidated, siliceous slime and of sedimentary origin. It is especially developed in Arkansas, and much used as a whetstone.

Nozzle. 1. A short tube, usually tapering, forming the vent of a hose or pipe. 2. The front nose-piece of a bellows or a blast pipe for a furnace. 3. A short piece of pipe with a flange on one end and a saddle flange on the other end. May be made of cast-iron, cast-steel or wrought-steel. 4. A side outlet attached to a pipe by such means as riveting, brazing, or welding.

O

Oakum. 1. Hards or tow of flax or hemp, used for calking seams, stopping leaks, etc. 2. The material obtained by untwisting and picking into loose fiber old hemp ropes.

Obsidian. 1. Extrusive igneous rocks which have cooled either without crystallization or with only partial crystallization. 2. A general name for volcanic glass. When used alone it implies a rhyolite-glass, but it is now much employed with a prefix as andesite-obsidian, basalt-obsidian.

Occurrence. In geology, the existence or presence of anything or phenomenon in any special position, or in any specified relations to other objects or phenomena.

Ocellar. Of, or pertaining to, or designating, a type of rock structure characterized by radiated, eyelike aggregates.

Oil sand. Porous sandstone from which petroleum is obtained by drilled wells.

Oil shale. Shale containing such a proportion of hydrocarbons as to be capable of yielding mineral oil on slow distillation.

Old red sandstone. A thick group of reddish sandstone, conglomerates and shales, of nonmarine origin, which constitute the Devonian system in parts of Great Britain and are regarded as equivalent in age to the normal marine Devonian strata. In North America the name was formerly applied to rocks of the Catskill group, which display some striking analogies to the Old Red Sandstone of Europe.

Oligocene. The second of the epochs into which the Tertiary period is at present ordinarily divided. Also the series of strata deposited during that epoch.

Oolite. A variety of limestone consisting of round grains like the roe of a fish.

Opencast. 1. A working in which excavation is performed from the surface, as in quarrying. 2. Exposed to the air like a quarry; as opencast working; a deposit worked opencast. Commonly called Open-cut; Open-pit.

Open connected. Applied to dredges in which a link is interposed between the buckets.

Open-cut system. See Overhand stoping; Stripping.

Open fault. See Fault.

Open pit mine. See Open-cut, also Opencast.

Open-pit quarry. A quarry in which the opening is the full size of the excavation. One open to daylight.

Open-working. Surface mining; quarrying; open-pit mining.

Orange sand. A deposit of sand, gravel, and pebbles, containing bowlders of northern Paleozoic rocks, occurring in the Mississippi valley; a diluvial deposit of the Champlain or quarternary epoch.

Orbicular granite. A granite containing numerous rounded segregations of minerals, chiefly dark silicates.

Ordovician. The second of the periods comprised in the Paleozoic era, in the geological classification now generally used. Also the system of strata deposited during that period.

Ore beds. Metalliferous aggregations occurring between or in rocks of sedimentary origin.

Orei. A quarry term applied to granite that has been rendered valueless by the alteration of its aegirite particles.

Oriental powder. An explosive consisting of a mixture of gamboge with potassium nitrate and chlorate.

Orthoclase. The monoclinic potash feldspar, $K_2O.Al_2O_3.6SiO_2$. Contains 16.9 per cent potash, K_2O.

Overall efficiency. Overall efficiency, of an air compressor, is the product of the compression efficiency and the mechanical efficiency.

Overblown. Burnt by reason of an excessive blast; said of steel made by the Bessemer process. (Standard).

Overburden. The waste which overlies the good stone in a quarry. Worthless surface material covering a body of useful mineral.

Overhand stoping. The working of a block of ore from a lower level to a level above. In a restricted way overhand stoping can be applied to open or waste-filled stopes that are excavated in a series of horizontal slices either sequentially or simultaneously from the bottom of a block to its top. Stull timbering or the use of pillars characterize the method. Filling is used in many instances.

Overhead cableway. A type of equipment for the removal of soil or rock. It consists of a strong overhead cable, usually attached to towers at either end, and on which a car or traveler may run back and forth. From this car a pan or bucket may be lowered to the surface and subsequently raised and locked to the car and transported to any position on the cable where it is desired to dump its contents.

Overhead charges. Those general charges or expenses which can not be charged up as belonging exclusively to any particular part of the work or product.

Overlap. The extension of younger strata beyond the limits of older ones lying beneath.

Oversize. That part of a crushed material which remains on a screen.

Ovoca classifier. A classifier of the free-settling type in which the heavy material is removed by a double-screw, continuous-flight conveyor, working up an inclined plane.

Oxonite. An explosive prepared by dissolving picric acid in nitric acid.

P

Packsand. A very fine-grained sandstone so loosely consolidated by a slight calcareous cement as to be readily cut by a spade.

Paleocene. The earliest of the epochs comprised in the Paleogene period, in the classification adopted by some geologists. Also the series of strata deposited during that epoch: they are regarded by some geologists as Upper Cretaceous and by others as Eocene.

Paleogene. The earlier of the two periods comprised in the Cenozoic era, in the classification adopted by the International Geologic Congress and used by many European geologists: it includes the Paleocene (if that be accepted), Eocene, and Oligocene epochs. Also the system of strata deposited during that epoch.

Paleolithic. Of, or pertaining to, the earliest known human culture, which is represented chiefly by unpolished stone implements. The paleolithic period was applied in Europe to the earliest known culture period, which was apparently sharply separated from the succeeding and much shorter period, called the Neolithic period, the two forming the Age of stone.

Paleozoic. One of the grand divisions or eras of geologic time, preceding the Mesozoic era. Also the group of rocks formed during the Paleozoic era, which comprises, in the generally adopted classification, the Cambrian Ordovician, Silurian, Devonian, and Carboniferous systems. The beginning of the Paleozoic was formerly supposed to be marked by the appearance of life on the earth and the lowest Paleozoic strata were supposed to be the oldest fossiliferous rocks of the earth's crust, but both suppositions are now known to be incorrect.

Panclastite. An explosive composed of liquid nitrogen textroxide mixed with carbon disulphide or other liquid combustible, in the proportion of three volumes of the former to two of the combustible.

Parting sand. Fine, dry sand, which is sifted over the partings in a mold to facilitate their separation when the flask is opened.

Peat. A dark-brown or black residuum produced by the partial decomposition and disintegration of mosses, sedges, trees, and other plants that grow in marshes and like wet places. It may be identified as the dark-colored soil found in bogs and swamps, commonly called muck, although technically the term "muck" should be restricted to such decayed vegetal matter as is impure and contains too much ash to burn readily. True peat consists principally of carbon, hydrogen, and oxygen, in varying proportions, and because of its high carbon content, it will ignite and burn freely when dry.

Peat bed. An accumulation of peat.

Peat bog. A bog containing peat; an accumulation of peat.

Pebble. 1. A small roundish stone, especially one worn round by the action of water; a pebblestone; also a gem occurring in the form of pebbles. 2. Transparent,

colorless quartz; rock crystal; as Brazilian pebble.

Pegmatite; Giant granite. An igneous rock, generally coarse grained but usually irregular in texture and composition, composed mainly of silicate minerals of large size, including quartz, feldspar, muscovite, biotite, tourmaline, 2beryl, lithia minerals, zircon, etc. Some pimatites carry minerals containing rare earth metals, tin, tungsten, tantalum, urannium, and others.

Percussion cap. See Detonator; Primer.

Percussion powder. Powder so composed as to ignite by a slight percussion; fulminating powder.

Percussive. Of, or pertaining to, percussion; operative or operated by striking, as a percussive drill.

Permissible explosive. An explosive similar in all respects to samples that passed certain tests by the Federal Bureau of Mines, and used in accordance with the following conditions: 1. That the explosive is in all respects similar to the sample submitted by the manufacturer for test. 2. That detonators—preferably electric detonators—are used of not less efficiency than those prescribed, namely, those consisting by weight of 90 parts of mercury fulminate and 10 parts of potassium chlorate (or their equivalents). 3. That the explosive, if frozen, shall be thoroughly thawed in a safe and suitable manner before use. 4. That the quantity used for a shot does not exceed 1½ pounds (680 grams), and that it is properly tamped with clay or other noncombustible stemming.

After an explosive has passed the required tests and its brand name has been published in a list of permissible explosives, it is not a permissible explosive if one or more of any of the following conditions prevail: 1. If kept in a moist place until it undergoes a change in character. 2. If used in a frozen or partly frozen condition. 3. If used in excess of 1½ pounds (680 grams) per shot. 4. If the diameter of the cartridge is less than that designated in the column "smallest permissible diameter." 5. If fired with a detonator or electric detonator of less efficiency than that prescribed. 6. If fired without stemming. 7. If fired with combustible stemming.

Persilicic. Containing more than 60 per cent of silica: said of some igneous rocks; same as and much to be preferred to Acid and Acidic, which it is replacing.

Petrifaction. The process of petrifying, or changing into stone; conversion of organic matter, including shells, bones, etc., into stone or a substance of stony hardness.

Petrify. To become stone. Organic substances, such as shells, bones, wood, etc., embedded in sediments, become converted into stone by the gradual replacement of their tissues, particle by particle, with corresponding amounts of infiltrated mineral matter. Thus not only the outward forms but even the minutest details of the organic tissues are preserved.

Petrography. That branch of petrology which treats of rocks as mineral aggregates, aside from their geologic relations, and is studied mainly by laboratory methods, largely chemical and microscopical. Also, loosely, petrology or lithology. The description and systematic classification of rocks.

Petrology. The science of rocks, treating of their origin, construction, etc., from all aspects and in all relations; lithology. It includes petrogeny and petrography.

Petrous. Hard, like stone; as, petrous phosphates; petrous marl.

Phosphate rock. A sedimentary rock containing calcium phosphate. The form in which the phosphate occurs is obscure. The three main classes which have been exploited in the United States are land rock, occurring in clayey, gravelly, or compacted beds below the surface of the earth; river rock, a darker variety obtained from river and stream beds, and the oolitic phosphates of Tennessee.

Piel. An iron wedge for piercing stone.

Piercer. A blasting needle.

Pinch. Kind of crowbar with a short projection and a heel or fulcrum at the end; used to pry forward heavy objects; a pinch.

Pioneer bench. The first bench in a quarry which is blasted out. It is usually at the top the rock to be quarried.

Pipe. 1. An elongated body of mineral A narrow portion of rich ore extending down the lode. 2. Also the name given to the fossil trunks of trees found in coal beds. 3. One of the vertical cylindrical masses of volcanic agglomerate in which diamonds occur in South Africa. 4. A tubular cavity, from a few inches to many feet in depth, occurring in calcareous rocks and often filled with gravel, sand, etc.

Pipe dog. A hand tool that is used to rotate a pipe whose end is accessible, consisting of a small short steel bar whose end is bent at right angles to the handle, and then quickly returned, leaving only enough space between the paws to slip over the wall of pipe.

Pipe grab. A clutch for catching and raising a well pipe.

Pisolite. A limestone composed of globular concretions, about thet size of a pea.

Pit. A large hole from which some mineral deposit is dug or quarried, or the mine itself, as a gravel pit, stone pit.

Pit kiln 1. A kiln sunk in the ground, as on a hillside. 2. An oven in which coke is made.

Place. 1. See In place; Also In Situ. 2. The part of a mine in which a miner works by contract is known as his "place" or "working place."

Placer deposit. A mass of gravel, sand, or similar material resulting from the crumbling and erosion of solid rocks and containing particles or nuggets of gold, platinum, tin, or other valuable minerals, that have been derived from rocks or veins.

Plaster mill. 1. A machine consisting of a roller or set of rollers for grinding lime or gypsum to powder. 2. A mortar mill.

Plaster of Paris. A plaster made from gypsum by grinding and calcining it; so called from its manufacture near Paris in France. In Canada this term has been adopted for gypsum in any form. It forms with water a paste which soon sets, and is used for casts, moldings, etc.

Pleistocene. The earlier of the two epochs comprised in the Quarternary period, in the classification generally used. Also called Glacial epoch and formerly called Ice age, Post-Pliocene, and Post-Tertiary. Also the series of sediments deposited during that epoch, including both glacial deposits and ordinary sediments. Some geologists formerly used Pleistocene as synonymous with Quarternary and included in it all post-

Tertiary time and deposits.

Pliocene. The latest of the epochs comprised in the Tertiary period, in the classification generally used. Also the series of strata deposited during that epoch.

Plug hole. Same as Block hole.

Plunger. In blasting, a rod designed for thrusting into a drill hole and ascertaining the position of the cartridge.

Pneumatic drill. A drill of either the reciprocating or hammer type operated by compressed air.

Pneumatic hoist. A device for hoisting operated by compressed air.

Pneumatic jig. A jigging machine in which an air blast performs the work of separation of minerals.

Point. 1. In quarrying, a type of wedge that tapers to a narrow, thin edge. 2. The end or bottom of a bore hole, as distinguished from the mouth or collar.

Pole drill. In boring, a system where a rigid connection is used between the drilling tools and the reciprocating beam.

Pop. A short bore hole drilled in a large rock with a view to reducing the size of the rock by means of a small explosive charge. Also called Pop hole; Pop shot.

Pop a bowlder. To place and explode a stick of dynamite on a bowlder so as to break it for easy removal.

Pop hole. A secondary drill hole.

Pop shot. Same as a block-hole shot.

Porpyry. Any igneous rock in which relatively large conspicuous crystals (phenocrysts) are set in a finer-grained or glassy groundmass.

Portland cement. A hydraulic cement consisting of compounds of silica, lime, and alumina. It is obtained by burning to semifusion an intimate mixture of pulverized materials containing lime, silica, and alumina in varying proportions within certain narrow limits, and by pulverizing finely the clinker that results.

Portland stone. 1. A yellowish white oolitic building limestone from the Isle of Portland, England. 2. A purplish-brown sandstone from Portland, Conn. 3. Concrete made with Portland cement, sand, and gravel.

Post drill. An augur (or drill) supported by a post.

Potato stone. A potato-like geode of quartz, having a central cavity lined with crystals.

Pot kiln. A small lime kiln.

Potstone. A coarse or impure variety of soapstone; so called from being easy to cut into pots owing to its softness.

Powder house. A magazine for the temporary storage of explosives.

Powder man. A man in charge of explosives in an operation of any nature requiring their use.

Powder monkey. A person employed at the powder house of a coal mine whose duty it is to deliver powder to the miners.

Powder mine. An excavation filled with powder for the purpose of blasting rocks.

Power drill. A rock drill employing steam, air, or electricity as a motive agent.

Pozzuolana. A leucitic tuff quarried near Pozzuoli, in Italy, and used in the manufacture of hydraulic cement. Artificial pozzuolana is made from slag, ash, etc. Also spelled Pozzolana and Pozzuolane.

Pressure blower. A machine or blower having either pistons, cams, or fans for furnishing an air-blast above atmospheric pressure.

Pressure box. A cistern at a considerable elevation, fed by a flume, ditch or pipe, to supply water under a head.

Pressure fan. 1. A fan supplying air under pressure. 2. A fan that forces fresh air into a mine as distinguished from one that exhausts air from the mine.

Primary. 1. Characteristic of or existing in a rock at the time of its formation; said of minerals, textures, etc., of rocks; essentially the same as Original 1, and contrasted with Derived, or Secondary, 1. 2. Formed directly by solidification from fusion or deposition from solution: said of igneous rocks and chemical sediments and contrasted with Derivative (little used). 3. Originally the same as the present pre-Cambrian, then extended to include the present Paleozoic; and later restricted to Paleozoic; finally abandoned and now obsolete.

Primary blasting. A term applied to the blasts by means of which the original rock ledge is broken into fragments.

Primary clay. Clay that is found in its place of formation (Webster). Residual clay.

Primary drilling. The process of drilling holes in a solid rock-ledge in preparation for a blast by means of which the rock is thrown down.

Prime. 1. To pour water to displace air and thus promote suction; as, to prime a pump. 2. Insert a detonator into a cartridge of explosive and attach it thereto.

Primer. A dynamite cartridge, or package of any explosive, which contains the detonator, whether blasting-cap or electric blasting-cap.

Priming horn. A miner's or quarryman's powder horn.

Priming powder. Detonating or fulminating powder.

Priming tube. A tube containing fulminating powder for firing a charge. A detonator.

Priming valve. 1. A safety valve on the working cylinder of a steam engine to discharge the priming. 2. A valve connected with the discharge pipe of a force pump through which the pump may be primed.

Profile. 1. An outline or contour; a drawing in outline, as in vertical section or the like. Specifically, the outline of a vertical section through a country or line of work, showing actual or projected elevations and hollows, generally with the vertical scale much greater than the horizontal.

Progressive powder. A gunpowder made so that it burns slowly at first, then with increasing rapidity, to avoid the extreme pressure caused by the explosion of powders in which the combustion is instantaneous. A slow-burning explosive. Compare Propellant explosives.

Propagated blast. A blast consisting of a number of unprimed charges of explosives and only one hole primed, generally for the purpose of ditching, where each charge is detonated by the explosion of the adjacent one, the shock being transmitted through the wet soil. In this method, one detonator fired in the middle of a line of holes is capable of bringing about the explosion of several hundred such charges.

Propellant explosives. Those explosives in which the velocities of combustion are regulated, either by chemical composition or by preparing the explosive in various shapes.

Prophylene-glycol dinitrate explosive. A term used by Dr. Charles E. Munroe to define an explosive containing the liquid ingredients named, in contradistinction to dynamite, which contains nitroglycerin. In commerce the term dynamite is loosely used to include any mixture containing a liquid explosive.

Propulsive. A term applied to the kind of force exerted by an explosive that tends to push out masses of rock rather than to break them up. See also Progressive powder.

Proving hole. 1. A borehole drilled for prospecting purposes. 2. A small heading driven to find a bed or vein lost by a dislocation of the strata, or to prove the quality of the ore in advance of regular workings.

Proximate analysis. The determination of the compounds contained in a mixture as distinguished from ultimate analysis, which is the determination of the elements contained in a compound.

Pudding stone. A conglomerate in which the pebbles are rounded. Compare Breccia.

Puffer. Small stationary engine used for hoisting material on construction work, in operating a haulageway, or for hoisting at shallow mines, especially in prospecting and development work.

Pulmotor. A mechanical device designed to perform artificial respiration in cases of asphyxia, electric shock, drowning, etc., by exhausting the lungs and filling them with oxygene-enriched air.

Pulp stone. A very large grindstone employed in pulp mills for crushing or grinding wood into fiber.

Pulsator. 1. A machine that beats or throbs in working, as a pulsometer pump. 2. A jigger or shaking machine used in diamond mining. 3. A device that sends puffs of compressed air into either end alternately of a kind of valveless rock drill. 4. A motor-driven air compressor that supplies compressed air to an electric channeler. It receives the exhaust from the channeling machine cylinder and thus utilizes the pressure of the exhaust.

Pulsator jig. A jig employing a fixed sieve and successive pulsions of rising water from a revolving plug cock with scarcely any downward return and suction. It has large capacity, occupies small space, and consumes a comparatively small amount of power.

Pulsometer. A kind of pump, with valves, for raising water by steam, partly by atmospheric pressure, and partly by the direct action of the steam on the water, without the intervention of a piston. Also called a Vacuum pump.

Pulverize. To reduce or be reduced to a fine powder or dust as by heating, grinding, or the like.

Pulverulent. That which may esily be reduced to powder.

Pumping jack. A device over a deep well for operating the pump by belt power.

Pushing jack. An implement for moving a large and heavy object, such as a railroad car, for a short distance.

Putty stones. Soft places of decomposed rock found in placer deposits.

Pyrite. A hard, heavy, shiny, yellow mineral, FeS_2, generally in cubic crystals. It may be distinguished from chalcopyrite by being of a paler yellow, harder and giving a black powder, whereas chalcopyrite gives a yellow powder. Marcasite has the same composition, but is white and crystallizes differently.

Pyrites. The term pyrites, as frequently used, literally means a mineral that strikes fire. It is applied to any of a number of metallic-looking sulphides, of which iron prites (pyrite) is the commonest; as copper prites (chalcopyrite), tin prites (stannite), etc. The term pyrite applies only to the iron disulphide, FeS_1.

Pyrometer. 1. An instrument for measuring the expansion of solid bodies by heat. 2. Any instrument for measuring degrees of heat, especially above those indicated by the mercurial thermometer.

Q

Quarry. An open or surface working, usually for the extraction of building-stone, as slate, limestone, etc.

Note: In its widest sense the term mines includes quarries, and has been sometimes so construed by the courts; but when the distinction is drawn, mine denotes underground workings and quarry denotes superficial workings. Open workings for iron ore, clay, coal, etc., are called banks or pits rather than quarries, the latter being defined as in 1 above.

Quarry bar. A horizontal bar supported at each end by legs and used to carry machine drills.

Quartz. Crystallized silicon dioxide, SiO_2

Queer creek. A fine-grained sandstone found in Ohio and used in the manufacture of inexpensive sharpening stones.

Queery. (Corn.). When the lode or rock on which the miner is driving partakes of the character of quarry stone, viz., in detached lumps by natural divisions, it is called queery ground, and is frequently worked with crowbars and levers instead of being blasted or gadded. A "queer of ground" is a detached rock.

Quicklime. Calcined calcium carbonate *(limestone). By the addition of water it* slakes and forms a hydrate of calcium.

Quickness. The property of an explosive by virtue of which it exerts a sharp blow or shattering effect on the material with which it is in contact. The quickest explosive of the dynamite class is the 60 per cent straight dynamite. Quick explosives are the ones particularly desired for mudcapping. For maximum effect for this purpose, they should be of high density and senstiveness.

Quicksand. Sand which is (or becomes, upon the access of water) "quick," i. e., shifting, easily movable or semi-liquid.

Quill. A slow burning fuse made formerly of the quill of a feather filled with powder.

R

Rackarock. An explosive consisting of about four parts of potassium chlorate to one part of nitrobenzine.

Ragstone. 1. Any hard, coarse-textured rock. 2. Especially, a rough, sandy, fossiliferous limestone of the Lower (Bath) Oolite in England. 3. Stone quarried in thin slabs, as for pavements.

Ratchet drill. A hand drill in which a lever carrying at one end a drill holder is revolved by a ratchet wheel and pawl. A drill used for boring slate.

Ratio of absorption. The percentage by weight that the absorbed water bears to the dry weight of the stone.

Reamer. 1. A tool for enlarging a bore-hole. 2. A kind of chisel for cutting two V-shaped grooves from a round blast-hole in the line of the desired rift.

Reaming. 1. Enlarging the diameter of a bore hole. 2. A quarryman's term for process of cutting grooves on opposite sides of drill holes in order to promote straight splitting of a stone.

Reconnaissance. 1. A preliminary examination or survey of a region in reference to its general geological characters. 2. An examination of a region as to its general natural features.

Redstone. A trade name for a red sandstone.

Reel. In blasting, a device for winding the leading wire for avoiding kinking and breaking the wire, and keeping it in good condition.

Refuge hole. A place formed in the side of an underground haulage way in which a man can take refuge during the passing of a train, or when shots are fired. Also called Refuge stalls.

Regolith. The layer or mantle of loose, incoherent rock material, of whatever origin, that nearly everywhere forms the surface of the land and rests on the hard or "bed" rocks. It comprises rock waste of all sorts, volcanic ash, glacial drift, alluvium, wind-blown deposits, vegetal accumulations, and soils.

Regular-lay rope. A rope in which the wires in each strand are twisted in opposite direction to the strands in the rope.

Relief holes. Bore holes, that are loaded and fired for the purpose of relieving or removing part of the burden of the charges to be fired in the main blast.

Relief map. A model of an area in which its inequalities of surface are shown in relief.

Rend-rock. A variety of dynamite used in blasting, consisting of nitroglycerin, saltpeter, wood pulp, and paraffin or pitch.

Respirator. A device, as a screen of fine wire or gauze, worn over the mouth or nose, by workmen who are obliged to breath air containing dust or smoke.

Resuscitate. To restore to animation or life; especially to restore from apparent death; revive; revivify; as, to resuscitate a drowned person. In cases of electric shock, asphyxiation from mine gases, etc., to revive by means of artificial respiration.

Revolving screen. A trommel, for sizing or classifying ore.

Rhabdomancy. Alleged divination by rod or wand when searching for minerals.

Rhyolite. A felsophyric to vitreous igneous rock composed essentially of quartz and alkalic feldspar, or of rock glass having substantially the same composition with or without biotite, hornblende, or pyroxene; liparite.

Rider. A person who rides with the trains of cars, to handle brakes, couple cars, signal, etc., as rope rider, trip rider.

Rifled. 1. A drill hole, in rock, that has become three-cornered while drilling. 2. said of a drill-core that has spiral markings.

Rim rock. The bedrock rising to form the boundary of a placer or gravel deposit.

Riparian rights. The rights of a person owning land containing or bordering on a watercourse or other body of water in or to its banks, bed, or waters. At the common law a person owning land bordering a non-navigable stream owns the bed of the stream and may make reasonable use of its waters.

Riprap A foundation or sustaining wall of stones thrown together without order.

River mining. Mining or excavating beds of existing rivers after deflecting their course, or by dredging without changing the flow of water.

River pebble. A term applied in Florida to a certain clas of phosphatic pebbles, or concretions, found in rivers as distinguished from land pebble phosphates.

Road metal. Rock suitable for surfacing macadamized roads and for foundations for asphalt and concrete roadways.

Roburite. An explosive containing, according to one formula, chlorinated dinitrobenzene and ammonium nitrate.

Rock. (a) Strictly, any naturally formed aggregate or mass of mineral matter, whether or not coherent, constituting an essential and appreciable part of the earth's crust. (b) Ordinarily, any consolidated or coherent and relatively hard, naturally formed mass of mineral matter; stone. In instances a single mineral forms a rock, as calcite, serpentine, kaolin, and a few others, but the vast majority of rocks consist of two or more minerals.

Rock breaker. Usually applied to a class of machine, of which Blake's rock-breaker is a type, and in which the rock is crushed between two jaws, both movable, or one fixed and one movable.

Rock butter. A variety of halotrichite. Called also Stone butter. (Standard)

Rock channeler. A machine used in quarrying for cutting an artificial seam in a mass of stone.

Rock crusher. A machine for reducing rock or ore to smaller sizes. Three principal types are the jaw-crusher, the gyratory, and the hammer crusher. See Rock breaker.

Rock drill. A machine for boring in rock, either by percussion, effected by reciprocating motion, or abrasion, effected by rotary motion. Compressed air is the usual motive power, but steam, electricity and electricity in combination with compressed air are also used.

The following are common types: Burleigh. The first rock drill manufactured in the United States. A term applied by miners to any heavy two-man drill. Chippy. A name applied to small piston drills. Jack hammer. A name given by the manufacturer to the first self-rotating drill made in the United States. Murphy. A hollow steel hand drill; also called Jap or Little Jap. Waugh. A stoping drill; sometimes called a stoper; also known in the Southern States as a warrior. Widow-maker. A name applied to stoping drills by reason of the unhealthy effect of the dust on the miner's lungs. Wiggle tail. A name applied to a stoping drill, derived from its actions when in operation. Water Leyner. A type of drill using hollow steel through which water flows to remove and allay dust. Also called Leyner-Ingersoll drill.

Rock flour. Very finely powdered rock material, formed by the grinding up of rocks beneath a glacier, deposited as part of the till, and not washed or blown away and deposited elsewhere as stratified drift or as loess.

Rock gypsum. Massive gypsum, sometimes crystalline, also microcrystalline or

fine grained, as in alabaster.

Rock meal. 1. A fine flour-like earth composed of shells of infusoria. 2. A white powdery variety of calcite, occurring as an efflorescence.

Rock milk. Soft pulverulent form of calcite found in caves or as an efflorescence.

Roll-jaw crusher. A crusher of the same general type as the Blake or Dodge (which see), but the moving jaw has a rolling instead of an oscillating motion.

Roll latten. Sheet brass polished on both sides.

Rolls. Cast-iron cylinders, either plan or fitted with steel teeth, used to break coal and other materials into various sizes. Applied to the type of crushing machinery in which the ore is broken between cylindrical rolls which rotate in a vertical plane.

Room and pillar. A system of mining in which the distinguishing feature is the winning of 50 per cent or more of the coal or ore in the first working. The coal or ore is mined in rooms separated by narrow ribs or pillars. The coal or ore in the pillars is won by subsequent working, which may be likened to top slicing, in which the roof is caved in successive blocks. The first working in rooms is an advancing and the winning of the rib (pillar) a retreating method. The rooms are driven parallel with one another, and the room faces may be extended parallel, at right angles, or at an angle to the dip. This method is applicable to flat deposits, such as coal, iron ore, lead, and zinc, etc., that occur in bedded deposits. Modifications of this method are: County of Durham system; Double-entry room and pillar mining: Double-room system; Double stall working; Heading and stall; Room and stoop; Single-entry room and pillar mining: Single-stall working; Square work; South Staffordshire thick-seam method; Stall and breast; and Triple-entry room and pillar mining.

Rope crab. An appliance used in cable drilling for recovering ropes that may have been accidentally dropped in the borehole.

Rope drilling. Drilling in the ground with a bit attached to the end of a rope to which a twisting motion is given. Sometimes called Jump drilling, as the rope with the bit is raised and dropped.

Rope drive. A replacement of belts by ropes for driving machinery.

Rope haulage. Any haulage system in which the cars are attached to ropes. Usually employed on level or nearly level roads or entries; sometimes with an endless rope.

Rotary pump. A pump in which the moving part is a piston, follower, or cam, rotating in a case, as distinguished from one that has a piston with to-and-fro motion. A centrifugal pump.

Rottenstone. A soft, light, earthy substance, consisting of silica in fine grains, resulting from the decomposition of siliceous limestone.

Rubberstone. A sharp-gritted Ohio or Indiana sandstone used for sharpening shoe knives; also called Shoestone.

Rubble. 1. Water-worn or roughbroken stones, broken bricks, etc., used in coarse masonry. 2. Rough stone as it comes from the quarry. 3. A quarryman's term for the upper fragmentary and decomposed portion of a mass of stone; brash.

Running rope. A flexible rope that will pass through blocks, and used for lifting or for moving heavy objects.

S

Safety catch. An automatic device for preventing the fall of a cage in a shaft or a car in an incline if the supporting cable breaks.

Safety fuse. A fuse consisting of a cotton or hemp tube holding a slow-burning composition for exploding charged blast holes. Commonly called Fuse.

Safety gate. An automatically-operated gate placed at the top of a mine shaft, or at landings, to guard the entrance, to prevent anyone from falling into the shaft.

Safety plug. In steam boilers, a bolt having its center filled with a fusible metal, screwed into the top of the fire box so that when the water becomes too low the increased temperature melts out the metal, and thus admits steam to the fire box to put out the fire.

Safety stop. 1. On a hoisting apparatus, a check by which a cage or lift may be prevented from falling. 2. An automatic device on a hosting engine designed to prevent over-winding.

Saint Peter's sandstone. An early Ordovician formation in Wisconsin and Minnesota.

Sand. 1. Separate grains or particles of detrital rock material, easily distinguishable by the unaided eye, but not large enough to be called pebbles; also, a loose mass of such grains, forming an incoherent arenaceous sediment.

Building sand, any hard, granular rock material finer than gravel and coarser than dust. The term indicates material comminuted by natural means. Quartz grains generally predominate in natural deposits, although such deposits commonly contain many other minerals. Glass sand, a sand of medium grain consisting of 98 to 100 per cent silica (SiO_2), used in glass making. Iron oxides should form less than 1 per cent of the mass. Molding sand, a sand used in making molds for casting metal.

2. In geology, any loose or moderately consolidated bed consisting chiefly of sand; often used in the plural, even in the name of a single deposit. 3. Specifically, sandstone; a technical usage in petroleum regions.

Sand bar. A bar of silt formed by currents in rivers and at their mouths, or of sand formed along beaches by tidal action.

Sand blast. 1. A mudcap in which sand is used instead of mud. 2. A stream of sand forcibly projected by air or steam for removing scale from metals. 3. The apparatus used to apply it.

Sand flag. Fine-grained sandstone, cleavable into flagstones.

Sand holder. A cavity in a pump-barrel to catch sand and keep it out of the way of the plunger or buckets.

Sand pipe. A tubular cavity from a few inches to many feet in depth occurring in calcareous rocks, and often filled with gravel, sand, etc. Also called Sand gall.

Sand pump. A cylinder with a valve at the bottom, lowered into a drill hole from time to time to take out the accumulated slime resulting from the action of the drill on the rock. Called also Shell pump and Sludger.

Sand seam. A quarry term for a more or less minute vein or dike of muscovite (white mica) with some quartz, in cases also with feldspar.

Sandstone. An indurated sedimentary rock formed of coherent or cemented sand.

Sandstone grit. 1. In geology, a coarse angular-grained sandstone. 2. In commerce, a sandstone well adapted for abrasive purposes and not necessarily having a coarse grain.

Sand trap. A device for separating sand and other heavy particles from running water.

Sand washer. An apparatus for separating sand from earthy substances.

Sap. The part of the rock in a quarry which is next to the surface or to joints and crevices and has been somewhat stained and softened by weathering.

Schist. A crystalline rock that can be readily split or cleaved because of having a foliated or parallel structure, generally secondary and developed by shearing and recrystallization under pressure.

Schistose. Characteristic of, resembling, pertaining to, or having the nature of schist.

Scoria. 1. An irregular, rough, clinker-like, more or less vesicular fragment of lava, thrown out in an explosive eruption or formed by the breaking up of the first-cooled crust of a lava flow.

Scraper conveyer. A mechanical device for conveying rock, ashes, etc., in a metal trough by means of scrapers attached to a rope or chain.

Screen analysis. The determination of weights of crushed material which passes through or is held on a series of screens of varying mesh.

Seam blast. A blast made by placing powder or other explosive along and in a seam or crack between the soil wall and the stone. intended to be removed.

Secondary. 1. (a) Having been acquired or formed by alteration or metamorphism since the formation of the rock; derived; said of some textures and minerals of altered rocks and contrasted with "original." (b) Formed of material derived from the erosion or disintegration of other rocks; derivative: said of clastic sedimentary rocks. 2. Same as Mesozoic, which has replaced it.

Secondary blasting. A term applied to the blasts employed in breaking up the larger masses of rock resulting from the primary blasts. Also termed Blistering or Bulldozing.

Secondary drilling. The process of drilling the so-called "pop holes" for the purpose of breaking the larger masses of rock thrown down by the primary blast.

Secondary mineral. A mineral resulting from the alteration of a primary mineral. Thus, original sulphides by oxidation change to sulphates, carbonates, and oxides, and these by hydration become hydrous forms of the same.

Section. 1. In geology, either a natural or an artificial rock-cut, or the representation of such on paper.

2. A term usually applied to a vertical exposure of strata. 3. A drawing or diagram of the strata sunk through in a shaft or inclined plane, or proved by boring.

Sedimentary rocks. Rocks formed by the accumulation of sediment in water (aqueous deposits) or from air (eolian deposits). The sediment may consist of rock fragments or particles of various sizes (conglomerate, sandstone, shale); of the remains or products of animals or plants (certain limestones and coal); of the product of chemical action or of evaporation (salt, gypsum, etc.); or of mixtures of these materials. Some sedimentary deposits (tuffs) are composed of fragments blown from volcanoes and deposited on land or in water. A characteristic feature of sedimentary deposits is a layered structure known as bedding or stratification. Each layer is a bed or stratum. Sedimentary beds as deposited lie flat or nearly flat.

Selenite. Gypsum in distinct crystals or broad folia.

Self-detaching hook. A self-acting hook for setting free a hoisting rope in case of overwinding.

Semi-wet method. A method of mixing the raw materials for Portland cement. The materials at first are dry; at some stage water is added, all subsequent steps being similar to those employed in the wet method. Also termed Semi-dry method.

Shaft. An excavation of limited area compared with its depth, made for finding or mining ore or coal, hoisting and lowering men and material, or ventilating underground workings. The term is often specifically applied to approximately vertical shafts, as distinguished from an incline or inclined shaft.

Shake. 1. A cavern, usually in limestone. 2. A close-joint structure in rock, due to natural causes, as pressure, weathering, etc. Used in the plural.

Shaking a hole. The enlargement of a blast hole, by exploding a stick of dynamite, so it will contain a larger amount of explosives for a big blast.

Shale. A fine-grained, fissile, argillaceous, sedimentary rock characterized by rather fragile and uneven laminae and commonly a somewhat splintery fracture. Often, but incorrectly, called slate by miners, quarrymen, well-drillers, and others.

Sheave. A wheel with a grooved circumference over which a rope is turned, either for the transmission of power or for hoisting or hauling. Any grooved wheel or pulley.

Sheet quarry. A term often used in granite quarrying, to designate a quarry having strong horizontal joints and a few vertical ones.

Shell limestone. A sedimentary rock composed chiefly of fragments of fossil shells.

Shingle. 1. Loosely and commonly, any beach gravel which is coarser than ordinary gravel, especially if consisting of flat or flattish pebbles. 2. Strictly and properly, beach gravel composed of smooth, well rounded pebbles of roughly the same size, the interstices between which are not filled with finer material as in ordinary gravel, and which gives out a musical note when trod upon.

Shooting-needle. A blasting needle; a metallic rod used in the stemming of a drill hole for the purpose of leaving a cavity through which the charge may be fired.

Short fuse. 1. Any fuse that is cut too short. 2. The practice of firing a blast, the fuse on the primer of which is not sufficiently long to reach from the top of the charge to the collar of the bore-hole. The primer, with fuse attached, is dropped into the charge while burning, and tamping may, or may not, be attempted. It is an extremely dangerous practice.

Short leg. One of the wires on an electric blasting cap, which has been shortened so

that when placed in the bore-hole, the two splices or connections will not come opposite each other and make a short circuit.

Short ton. A ton of 2,000 pounds avoirdupois, a long ton being 2,240 pounds avoirdupois. Also called Net ton.

Shot drill. An earth-boring drill using steel shot as an abrasive.

Shot-fast. Coal mined by blasting. (Gresley) Shot-off-the-solid.

Shot firer. A man whose special duty is to fire shots or blasts. Also Shot lighter.

Shot hole. The borehole in which an explosive is placed for blasting.

Shot lighter. See Sot firer.

Shrinkage-crack. One of a series of cracks, or of filled-up cracks, often seen on rock surfaces; supposed to have resulted from the drying and shrinking of the layer while it was plastic mud. Called also Suncrack.

Shute. See Chute.

Side-dumper. An ore, rock, or coal car that can be tilted sidewise and thus emptied.

Side line. A line attached to the side of a dredge and used to hold the dredge in place during operations.

Silex. See silica. 1.

Silica. 1. An oxide of silicon, SiO_2. Occurs in nature as a mineral of economic importance in quartz, chalcedony, chert, flint, opal, diatomaceous earth and sandstone. The most abundant constituent of the earth's crust. See also Agate, Quartz, Glass sand. Also known as Silex, and used for lining tube mills.

2. Very fine white disintegrated chert, used in pottery manufacture.

Silicalite. Wadsworth's name for rocks composed of silica, much as diatomaceous earth, tripoli, quartz, lydite, jasper, etc.

Silicate. A salt or ester of any of the silicic acids. In mineralogical chemistry the silicates are of great importance, forming by far the largest group of minerals.

Silurian. The third in order of age of the geologic periods comprised in the Paleozoic era, in the nomenclature in general use. Also the system of strata deposited during that period.

Silver sand. A sharp fine sand of a silvery appearance used for grinding lithographic stones, etc.

Single-bench quarrying. Quarrying a rock ledge as a single bench the full height of the quarry face.

Single-jack. A light single-hand hammer used in drilling, especially in metal mines. The hammer is used in one hand while the drill is held by the other.

Single-rope haulage. A system of underground haulage in which a single rope is used, the empty trip running in by gravity. Engine-plane haulage.

Single shot. A charge in one drill hole fired at one time as contrasted with a multiple shot where charges in a number of holes are fired at one time.

Sinker bar. A bar added to the drill tools simply to give the required force to the upward jar. It is never allowed to pound upon the drill.

Sinker-bar guides. Bars of iron (usually 4) fitted to the drill tools in order to increase their girth anr render it impossible for the drill to deviate.

Skip. 1. A large hoisting bucket, constructed of boiler plate, which slides between guides in a shaft, the ball usually connecting at or near the bottom of the bucket so that it may be automatically dumped at the surface. 2. An open iron vehicle or car on four wheels, running on rails and used specially on inclines or in inclined shafts. Sometimes spelled Skep.

Skip pit. The depression into which the skip descends when at the bottom of the incline to bring its top below the discharge chute of the scale car or bin.

Skip road, or way. A track of T-rails, spiked to wooden sleepers, on which a skip runs.

Slabstone. A rock that readily splits into flags or slabs; flagstone.

Slag. 1. The vitreous mass separated from the fused metals in smelting ore. 2. Volcanic scoria.

Slag cement. A hydraulic cement made by grinding granulated blast-furnace slag with slaked lime.

Slate. A dense, fine-textured metamorphic rock whose separate minerals are indistinguishable to the unaided eye, and which has an excellent parallel cleavage, so that it breaks into thin plate or pencil-like shapes. A coal miner's term for any shale or slate accompanying coal; also sometimes applied to bony coal.

Slip-spear. A tool for extracting tubing from a bore-hole.

Sludge pump. A short iron pipe or tube fitted with a valve at the lower end, with which the sludge is extracted from a bore-hole.

Slurry. 1. A thin watery mud, or any substance resembling it. 2. A thin cement or motar used to repair furnace linings. 3. A watery mixture of the powdered raw materials of hydraulic cement.

Smokeless powder. An explosive consisting of nitrocellulose in a more or less completely gelatinized condition.

Snake hole. A bore-hole driven horizontally or nearly so and approximately on a level with the quarry floor; also a bore-hole driven under a bowlder for containing a charge of explosives. In quarry work it is called a "lifter."

Snub. 1. To increase the height of an undercut by means of explosives or otherwise. 2. To check the descent of a car, by a turn of a rope around a post.

Soapstone. 1. A metamorphic rock of massive, schistose, or interlocking fibrous texture and soft unctuous feel, composed essentially of steatite or talc, which is regarded as secondary after some ferromagnesian mineral. 2. As used loosely by miners, well drillers, and others, any soft unctuous rock, such as micaceous shale or sericitic schist.

Soft phosphate. A term used in Florida which is applied arbitrarily to anything phosphatic that is not distinctly hard rock.

Sow. A tool used in sharpening machine-drill bits.

Spacing. In quarrying the distance between drill holes in a row.

Spad. See Spud.

Specific gravity. The ratio of the weight of a body to that of an equal volume of some standard substance, water in the case of solids and liquids, air in the case of gases; numerically equal to the density.

Spent shot. A blast hole that has been fired but has not done its work.

Spew. The cauliflower-like blowout or outcrop of a lode that extends beyond the liimts of the defined vein deeper down.

Spire. The tube carrying the train to the

charge in a blast hole. Also called Reed or Rush, because these, as well as spires of grass are used for the purpose. A kind of fuse.

Spring. To enlarge the bottom of a drill hole by small charges of a high explosive in order to make room for the full charge; to chamber a drill hole.

Spudding bit. A broad dull drilling tool for working in earth down to the rock.

Squib. 1. A tapered paper tube, about 7 inches long, filled with fine gunpowder, one end of the tube being treated with chemicals so as to form a slow burning match, which, when ignited, burns so slowly as to give the miner time to reach a place of safety before the explosion. When used, the squib is placed in the needle hole, or blasting barrel, through the tamping, with the match end of the squib outward.

2. Small charge of powder exploded in the bottom of a drill hole, to spring the rock, after which a heavy shot is fired. A springing shot.

Squib shot. A blast with a small quantity of high explosive fired at some point in the bore hole for the purpose of dislodging some foreign material which has fallen into it.

Starter. 1. A drill used for making the upper part of a hole, the remainder of the hole being made with a drill of smaller gage known as a follower.

Steel needle. An instrument used in preparing blasting holes, before the safety fuse was invented.

Stemming. A term applied in mining literature to the inert material used on top of a charge of powder or dynamite, while tamping is reserved to indicate only the process of compresssing the stemming in place.

Stope. 1. An excavation from which the mineral has been extracted, either above or below a level, in a series of steps. A variation of step. Usually applied to highly inclined or vertical veins. Frequently used incorrectly as a synonym of room, which is a wide working place in a flat mine.

2. To excavate ore in a vein by driving horizontally upon it a series of workings, one immediately over the other, or vice ypversa. Each horizontal working is called a stope (probably through a corruption of step), because when a number of them are in progress, each working face being a little in advance of the next above or below, the whole face under attack assumes the shape of a flight of stairs. When the first stope is begun at a lower corner of the body of ore to be removed, and, after it has advanced a convenient distance, the next is commenced above it, and so on the process is called overhand stoping. When the first stope begins at an upper corner, and the succeeding ones, are below it, it is underhand stoping. The term stoping is loosely applied to any subterranean extraction of ore except that which is incidentally performed in sinking shafts, driving levels, etc., for the purpose of opening the mine.

Stoping drill. A small air or electric drill, usually mounted on an extensible column, for working stopes, raises, and narrow workings.

Straight dynamite. A high explosive consisting essentially of 20 to 60 per cent nitroglycerin and an active base or absorbent.

Streak. The color of the powder of a mineral as obtained by scratching the surface of the mineral with a knife or file or, of not too hard, by rubbing it on an unpolished porcelain surface.

Strip. To remove from a quarry, or other open working, the overlying earth and disintegrated or barren surface rock.

Stripping. 1. An open-pit working. **2.** See Strip, 1. **3.** The earth, rock, or soil so removed.

Sturtevant balanced-rolls. Rolls in which all four boxes are movable and held in position by springs. The idea is to divide the thrust whenever the springs yield and thus reduce internal stresses.

Sturtevant grinder. A disk grinder in which one disk is stationary and the other rotates. The stationary disk is moved out of center from time to time, so that any groove which forms can be ground out.

Sturtevant ring-roll crusher. A crusher similar to the Kent roller mill, which see.

Sturtevant roll-jaw crusher. A crusher in which the motion of the upper part of the jaws is like that of the Dodge crusher, while the lower parts of the jaws, of cylindrical surfaces of varying radii, grind the ore between them.

Suction dredge. A dredge in which the material is lifted by pumping through a suction pipe.

Suction pipe. That part of a pump where the water enters.

Suction primer. A pump auxiliary to a steam pump, used to exhaust the air from the main chamber, as a preliminary to the use of steam.

Suction pump. A pump wherein, by the movement of the piston, water is drawn up into the partial vacuum formed under the retreating bucket on the upstroke, reflux being prevented by a valve in the pipe. Theoretically the suction pump will lift water 34 feet, but practically only about 26 to 28 feet.

Sulphur. 1. A non-metallic element occurring naturally in large quantities either native or in various sulphides. Native sulphur occurs in yellow orthorhombic crystals, in masses, crusts, and powder. Symbol, S; atomic weight, 32.06; specific gravity, 2.06. **2.** Iron pyrite, occurring in coal seams. Also iron sulphide (pyrite) occurring with Wisconsin and Missouri zinc ore. In southern States, synonymous with Pyrite.

Sump. An excavation in the coal or rock made below the gangway or in the bottom of a shaft to collect mine water. The gangway ditches or drains empty into it, and the pump draws the water from it.

Sump fuse. A waterproof fuse for use in a sump.

Sump shot. A blast made near the center of a shaft that is being sunk, to make a collecting place for water.

Syenite. Any granular igneous rock composed essentially of orthoclase, with or without microcline, albite, hornblende, biotite, augite, or corundum.

Symon's disk crusher. A mill in which the crushing is done between two cup-shaped plates that revolve on shafts set at a small angle to each other. These disks revolve with the same speed in the same direction and are so set as to be widest apart at the bottom. Feed is from the center, and the material is gradually crushed as it nears the edge, and is then thrown out by centrifugal force.

T

Tactite. A rock of more or less complex mineralogy formed by the contact metamorphism of limestone, dolomite or other calcareous rocks into which foreign matter from the intruding magma has been introduced by hot solutions.

Tail. (Also plural). The inferior, less valuable, or refuse part of anything; foots, bottoms, dregs; sediment.

Tail house; Tail mill. The buildings in which tailings are treated. (Raymond).

Tailings. The parts, or a part, of any incoherent or fluid material separated as refuse, or separately treated as inferior in quality or value; leavings; remainders; dregs.

Tail rope. 1. The rope that is used to draw the empties back into a mine in a tail-rope haulage system. 2. A counter-balance rope attached beneath the cage when the cages are hoisted in balance. 3. A hemp rope used for moving pumps in shafts.

Tail-rope haulage. A system of rope haulage by which the full hutches (cars), with the tail rope attached behind, are drawn by a main rope passing over a drum, and the empty hutches, with the main rope attached, are drawn back again by the tail rope passing over another drum.

Talc. A hydrous magnesium silicate, $H_2O.3MgO.4SiO_2$. Has a greasy or soapy feel and is soft and easily cut. Occurs in beds more or less impure and is then known as statite or soapstone. Also called Potstone because it has been used for pots, owing to the ease with which it is worked and to its resistance to ordinary heats. French chalk is a variety used for crayons.

Tamp. To fill (usually with clay) the bore hole or other opening through which an explosive charge has been introduced for blasting.

Tamper. 1. One who tamps. 2. An implement for tamping; a tamping iron or tamping bar. Sometimes made of wood, copper, or iron with a copper tip. See Tamping bar.

Tamping. In common mining parlance the word tamping is now, and for a long time has been used, to designate both the inert material used on top of a charge of powder or dynamite, and the operation of compressing it into place. See Stemming, which is the term preferred for the inert material, while tamping ore correctly is the act of compressing the stemming.

Tamping bar. An iron bar, shod with copper to obviate striking fire, used for compressing the stemming. See Tamper.

Tamping plug. A plug of iron or wood used instead of tamping material (stemming) to close up a loaded blast hole.

T-Chisel. A boring tool with its cut-edge made in the form of the letter T.

Tectonic. Pertaining to the rock structures and external forms resulting from the deformation of the earth's crust.

Telpherage. An automatic aerial transportation system, especially that system in which the carriages having independent motors are run on a stout wire conducting an electric current from which the motive power is derived; an aerial electric tramway.

Tertiary. The earlier of the two geologic periods comprised in the Cenozoic era, in the classification generally used. Also the system of strata deposited during that period.

Test pit. A shallow pit sunk in search of mineral.

Thaw house. A small building, designed for thawing dynamite, of such size as to provide enough thawed dynamite for the day's work. Thawing houses should be heated either with hot water or exhaust steam in such a manner that the explosives can not come in contact with the heated metal or lie directly over the heated metal.

Thawing. The warming of frozen dynamite until it becomes soft and plastic. Thawing should be done carefully, slowly, and according to directions issued by the manufacturers of the explosives.

Thawing kettle. A double kettle, built somewhat like a farina boiler, having two compartments, an outer compartment, which is filled with hot water and which entirely surrounds the inner compartment that contains the dynamite to be thawed. It is provided with a lid for retaining the heat.

Tiger. A device, as a fork, for supporting a continuous series of boring rods or tubes while raising or lowering them in the hole.

Tightset. A quarrymen's term, equivalent to blind seam, or incipient joint.

Tip; Tipple. A platform upon which a pair of iron tram rails, fixed upon an axle and attached to a lever, are bolted down, for emptying cars into wagons, boats, bins, etc.

Tipple. The place where cars are tipped or dumped; the dump; a cradle-dump.

Toe. 1. The burden of material between the bottom of the bore hole and the free face. 2. It is sometimes used to designate the bottom of the bore hole itself as distinguished from the heel, collar or mouth of the bore hole, which is the open end.

Tonite. An explosive consisting of about equal weights of guncotton and barium nitrate. It is used for blasting.

Ton mile. In railroading, a standard measure of traffic, based on the rate of carriage per mile of each ton of freight.

Tool extractor. An implement for grasping and withdrawing boring tools when broken or detached in a bore, as of an oil well, etc. Called also Tool grab.

Tool nipper. A person whose duty it is to carry powder, drills and tools to the various levels of the mine and to bring such tools and drills as have been dulled by use to the surface.

Touchstone. A black siliceous stone, allied to flint.

Train boy. A boy who rides on a trip, to attend to rope attachments, or to signal in case of derailment of cars, etc. A trip rider.

Train mile. One mile traveled by one train; used as a unit of railroad operation in order to estimate economy in running expenses.

Tramp iron. Stray pieces of drill steel, picks, tools, etc., which are found in ore. Often removed by a magnet as ore is fed into a crusher.

Tram rope. A hauling rope, to which the cars are attached by a clip or chain, either singly or in trips.

Tramway. 1. A roadway having plates or rails on which wheeled vehicles may run. A tramroad. 2. A suspended cable-system along which material, as ore or rock, is

transported in suspended buckets. See Aerial tramway.

Trap. Trap rock. A general name for dark fine-grained igneous rocks, particularly lavas or dikes. A useful field name for any dark, finely crystalline, igneous rock. It is a Swedish name from the occurrence of such rocks in sheets that resemble steps, "trapper."

Traveler. 1. A truck rolling along a suspended rope for supporting a load to be transported. 2. A crab or winch moving on an elevated track, used especially in erecting steel bridges or other large work; also a traveling crane.

Trip. 1. The cars hauled at one time by mules, or by any motor, or run at one time on a slope, plane, or sprag road. A train of mine cars. 2. An automatic arrangement for dumping cars; a tipper; a kickup.

Tripod drill. A reciprocating rock drill mounted on three legs and driven by steam or compressed air. The drill steel is removed and a longer drill inserted about every two feet.

Tripoli; Tripolite. An incoherent, highly siliceous sedimentary rock composed of the shells of diatoms or of radiolaria, or of finely disintegrated chert.

Tripper. 1. One who trips. 2. A tripping device or mechanism, as a device for causing the load on a conveyor to be discharged into a hopper, bin, etc.; a trip. An automatic car dump.

Trip rider. One who rides on trips and whose duty it is to throw switches, give signals, make couplings, etc. Also called Rope rider.

Trommel. A revolving sieve for sizing mineral. Also called according to its various uses, Sizing trommel, Washing drum, Washing trommel.

Tube mill. A revolving cylinder, usually lined with silex, nearly half filled with glacial or water-worn flints, used for fine grinding of certain ores, preliminary to further treatment. The material to be ground, mixed with water, is fed through a trunnion at one end, and passes out of the opposite trunnion, as a slime.

Tufa. A chemical sedimentary rock composed of calcium carbonate or of silica, deposited from solution in the water of a spring or of a lake or from percolating ground water; sinter. Should not be confused with Tuff.

Tuff. A sedimentary rock composed of fine material—volcanic dust, so-called ash and cinders, and lapilli—explosively ejected from a volcano. Tuff may or may not be deposited in water; it may be either heterogeneous or rather well sorted, and it may be either incoherent or indurated.

Tunnel blasting. A method of heavy blasting in which a heading is driven into the rock and afterwards filled with explosives in large quantities, similar to a bore hole, on a large scale, except that the heading is usually divided in two parts on the same level at right angles to the first heading, forming in plain a "T," the ends of which are filled with explosives and the intermediate parts filled with inert material like an ordinary bore hole. Similar to Gopherhole blasting.

Tunnel kiln. A lime kiln having a tunnel for the consumption of coal, as distinguished from a flame-kiln, where wood is burned.

Tunnel system. A method of mining, in which tunnels or drifts are extended at regular intervals from the floor of the pit into the ore body. The extension of the drift beyond the working face is made great enough to facilitate the handling of several cars at a time. The ore is mined above the drift level, and the cars are loaded by lifting short boards which span an opening, through the lagging on, and above, the center line of the drift. The method avoids the construction of raises and chutes, and facilitates the filling of the cars.

U

Undercut quarry. A quarry in which the walls slant outward (overhang working face) so as to make the floor space wider with increasing depth.

Underhand stoping. Mining downward. The stope may start below the floor of a level and be extended by successive horizontal slices, either worked sequentially or simultaneously in a series of steps. The modifications consist in the working of the block by a series of slices parallel with the dip, each slice being worked from the top down and the slices being taken in sequence. The stope may be left as an open stope or supported by stulls or pillars.

Undersize. That part of a crushed material which passes through a screen.

Updraft kiln. A kiln in which the heat enters the chamber from the bottom and passes up through the ware.

V

Vacuum fan. A fan for creating suction or partial vacuum. An exhaust fan.

Vacuum pump. 1. A pump in which water is forced up a pipe by the difference of pressure between the atmosphere and a partial vacuum. 2. A pump for creating a partial vacuum in a closed space.

Vanadium steel. Steel alloyed with vanadium (usually 0.10 to 0.15 per cent), an element which strengthens the steel and serves to remove the oxygen and possibly nitrogen.

V.-cut. In mining and tunneling, a cut where the material blasted out in plan is like the letter V; usually consists of six or eight holes drilled into the face, half of which form an acute angle with the other half.

Vent. A small passage made with a needle through the stemming, for admitting a squib to enable the charge to be lighted.

Venturi meter. A water meter in which the flow is ascertained from the increase in velocity and consequent loss of pressure caused by the reduction in the cross-sectional area of the pipe through which the water flows.

Verifier. A tool used in deep boring for detaching and bringing to the surface portions of the wall of the bore-hole at any desired depth.

Vigorite. An explosive resembling dynamite No. 2, and consisting of nitroglycerin with a more or less explosive dope.

Volcanic rock. Any rock of volcanic origin: volcanic igneous rocks are those erupted as molten masses, forming lava flows, dikes in the crater walls, volcanic plugs, etc.; volcanic sedimentary rocks are the fragmental materials ejected in explosive

eruptions, forming tuff, agglomerate, etc.

Volcanic sand. Finely divided fragments of lava produced by volcanic explosions.

Vulcan powder. A dynamite composed of nitroglycerin (30 parts), sodium nitrate (52.5), charcoal (10.5), and sulphur (7). Used in mining and blasting.

W

Wacke. Residual sand and clay formed by the decay of diabase, basalt, basaltic tuff, and similar rocks.

Wagon drill. A reciprocating drill operated by steam or compressed air. It is similar to a tripod drill, but is mounted on a truck and employs long steel which does not require frequent change.

Walking. The movement forward or backward of a dredge by first winding up on one side and then the other, swinging the boat from side to side and thereby advancing with a slight offsetting to the side.

Walking crane. A light crane traveling on an overhead channel iron and a single rail vertically beneath this in the floor.

Wash. 1. A Western miner's term for any loose, surface deposits of sand, gravel, bowlders, etc. 2. Auriferous gravel. 3. Coarse alluvium; an alluvial cone. 4. The dry bed of an intermittent stream, sometimes at the bottom of a canon, as the Amargosa wash. Also called Dry wash. 5. To subject, as earth, gravel, or crushed ore, to the action of water to separate the valuable material from the worthless or less valuable.

Water inch. The discharge from a circular orifice 1 inch in diameter with a head of one line (one-twelfth inch) above the top edge commonly estimated at fourteen pints per minute; an old unit of hydraulic measure.

Water lime. 1. Hydraulic lime. 2. A Silurian limestone formation overlying the Salina proper of New York. Hydraulic lime is made from it.

Well-drill holes. Holes drilled by means of an apparatus known as the well drill, or similar to that, and used for blasting on comparatively large scale. Such holes are usually 5 or 6 inches in diameter and from 30 to 150 feet deep.

Wet method. In the manufacture of Portland cement, mixing of raw materials in a wet condition. This method is usually employed where marl is used, the marl being usually wet when excavated and is kept wet during the entire process until it reaches the kilns.

Wheel scraper. A scraper mounted upon an axle supported by a pair of wheels. It affords an easy means of conveying a loaded scraper to a dumping ground.

Whim. A large capstan or vertical drum turned by horse power or steam power, for raising coal, or water, etc., from a mine.

Whinstone. Basaltic rock; also, among miners, any of various other dark resistant rocks, as chert or diabase. Greenstone.

Whip. The simplest horse-power hoisting machine, consisting of a fixed pulley and a hoisting rope passing over it, to which the animal is directly attached. When used with a derrick or gin called Whip-and-derry.

White gunpowder. A blasting compound formed of potassium chlorate, potassium ferrocyanide and sugar.

Whiting. A white levigated and washed chalk used as a pigment and for polishing. According to its quality, it is known variously as Spanish white or whiting and Paris white.

Widemouth socket. A well borer's fishing tool, in which the socket is fitted with a bellmouth, nearly the full bore of the casing, thus making it easy to grip the ends of broken poles or the like, when lost at the bottom of a well.

Williams hinged hammer crusher. A crusher with a rotating central shaft carrying a number of hinged hammers, which fly out from centrifugal force, crushing the feed against the casing.

Winch; Windlass. A man-power hoisting machine, consisting of a horizontal drum with crank handles. Also, now operated by steam, as a steam winch.

Winze. A vertical or inclined opening, or excavation, connecting two levels in a mine, differing from a raise only in construction. A winze is sunk underhand and a raise is put up overhand. When the connection is completed, and one is standing at the top, the opening is referred to as a winze, and when at the bottom, as a raise, or rise.

Wiper. A rod on which is held a piece of cotton waste or to her abserbent material and used for drying a drill hole before charging with black powder.

Wollastonite. A white mineral of the pyroxene group consisting of silicate. ($CaSiO_3$) of calcium and a common product of the metamorphism of limestone by intrusive igneous rocks. Often in aggregates of flat prismatic crystals without distinct crystal planes or faces.

Working face. The place at which the work is being done in a breast, gangway, airway, chute, heading, drift, adit, or crosscut, etc.

X

Xanthophylite. A hydrous silicate of magnesium, calcium and aluminum, occurring in crusts or implanted globular forms.

Xenolith. A fragment of other rock or of an earlier solidified portion of the same mass inclosed in an igneous rock; an inclusion; an enclave.

Xyloidine. An explosive compound produced by the action of nitric acid upon starch or woody fiber, resembling gun cotton.

Y

Yard service. Transportation of rock from the quarry bank until the time it reaches the main transportation lines.

Z

Zeolite. A generic term for a group of minerals occurring in cracks and cavities of igneous rocks, especially the more basic lavas.

Zobtenite. Roth's name for metamorphic rocks with the composition of gabbros, i. e., rocks not certainly igneous. The name is derived from the Zobtenberg, a Silesian mountain.

Zoic. In geology, containing fossils, or yielding evidence of contemporaneous plant or animal life: said of rocks.

Zone. 1. In geology, used in the same sense as horizon to indicate a certain geological level or chronological position, without reference to the local attitude or dip of the rock.

CATALOGUE SECTION

PUBLISHER'S NOTE

If you are an operator of a sand, gravel, stone, cement, gypsum or lime plant, you have received this copy of the HAND BOOK free of charge and with the best compliments of the publishers.

As an operating head of such a plant you will, from time to time, want to buy equipment and supplies. It is for your service at these times that this section of the HAND BOOK is tendered.

Don't forget to mention Pit and Quarry HAND BOOK when writing about any of the equipment or supplies catalogued or listed herein.

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PRODUCTS

Aerial Wire Rope Tramways in various systems to provide economical transportation under all conditions. Wire Ropes for all purposes. (See pages 296, 297).

USES AND ADVANTAGES

Leschen Tramways are being successfully used to transport practically all kinds of material, especially cement, lime, etc., and the material for the manufacture thereof; also sand, gravel and rock. They are economical carriers because

- —they can often be run by gravity
- —they are not affected by weather conditions
- —installation and operating costs are not materially increased by irregular ground conditions
- —maintenance and operating costs are low
- —they are correctly designed and made of high-grade material throughout.

SYSTEMS

In order to correctly meet all conditions of aerial transportation, Leschen Tramways are furnished in various systems. The following are the most commonly used:

The Leschen Heavy Duty Friction Grip system is designed particularly for long distances and heavy capacities, yet its economical use is not limited by these conditions. From five tons per hour to several hundred tons, and from a few hundred feet to many miles are all within its range as to capacity and length. Hundreds of tramways equipped with this screw type friction grip are in use.

A Leschen Friction Grip Tramway that carries crushed stone. Capacity is 150 tons per hour. Length is 4,000 feet.

This Leschen Automatic Tramway transports sand from pit to railroad. Installed in 1906.

The Leschen Automatic system, as its name implies, is automatically loaded and discharged. The main feature here is a saving in labor, as but one man is required.

The Leschen Two-Bucket or Oscillating system, is used extensively for short lines. Although sometimes built as a power driven tramway, its more general use is where gravity operation is possible. This type of tramway is extensively used for carrying coal from mountain-side mine to railroad, although it can be readily adapted to other purposes.

A BRIEF LIST OF INSTALLATIONS

Some of the users of Leschen Tramways in the pit and quarry field are: Best Bros. Keene's Cement Co., Medicine Lodge, Kansas; Ballou White Sand Co., Millington, Ill.; Crescent Portland Cement Co., Wampum, Pa.; Clinch Mountain Silica Sand Co., Mendota, Va.; Hugh Nawn Contracting Co., Gilboa, N. Y.; International Lime Co., Sumac, Wash.; Lehigh Portland Cement Co., Oglesby, Ill., and Metaline Falls, Wash.; Three Forks Portland Cement Co., Hanover, Mont.

PRELIMINARY ESTIMATE

Our Engineering Department will be glad to advise with you as to the practicability of an Aerial Tramway for your particular work and to submit an estimate to you, if you will furnish us information as suggested below:

1. Give length of tramway in straight line. If horizontal curves cannot be avoided, give angle of each curve. 2. Give difference in elevation between terminal points, and state which terminal is at higher elevation. If possible, send rough sketch showing profile of ground. 3. State material to be handled and give its weight per cubic foot in the form to be carried over tramway. 4. State how many tons (2,000 lbs.) you wish to transport per hour. A profile made from an accurate survey is required if final price is wanted.

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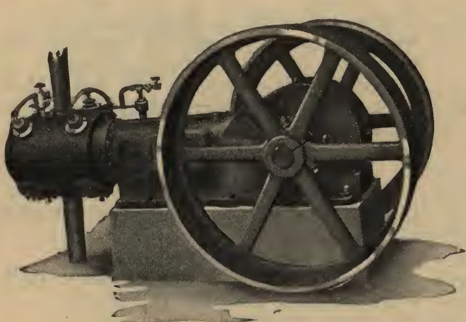

Piston displacement, cubic feet per min.	Air pressure, pounds	Horse-power* required
69	100-125	10 - 11
107	50-100	13 - 17
139	100-125	21½- 22½
176	80-100	24 - 26
218	50- 70	27 - 29½
314	15- 40	20 - 38
250	100-125	43 - 47
360	80-100	56 - 60
562	30- 50	57 - 72
723	15- 30	48 - 67
392	100-125	67 - 74
534	60-100	75 - 92
788	30- 50	78 - 99
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587	100-125	93 - 97
863	50- 80	110 -127
1197	15- 40	86 -137

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BRISTOL'S PATENT STEEL BELT LACING

Made of cold rolled steel in several styles corresponding to the methods in hand lacing. This provides a steel fastener for all kinds of belts including leather, composition, fabric, etc.

This belt lacing is made in sizes to fit belts of all dimensions up to large conveyor belting.

To apply, no special tools are required, only a hammer is necessary. It is almost as simple as driving a nail to lace a belt with Bristol's Steel Belt Lacing. The process—square the ends of the belt—place the lacing over—drive through with a hammer—turn over the belt—clench the points of the lacing. The wedge-shaped-points push aside the fibers of the belt without tearing them. The points are embedded in the belt so that it gives a smooth surface over the pulley.

This lacing has been used for over 30 years and is still the most up-to-date method, also the cheapest, quickest, and in every way efficient.

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Made of cold rolled steel, curved to conform with the surface of the pulley.

Made for every width and thickness of belts.

No special tools required to apply Bristol's Steel Belt Plates. Anyone with a hammer and an awl can make the most satisfactory kind of a joint.

Applied with a Bi-furcated Rivet which exactly fit into the countersunk holes of the plates and provides a smooth surface which will not catch on hands or clothing. Also holds the plate so securely in place there is no working loose or tearing out.

Suitable for all kinds of belts, including leather—rubber—composition—fabric—etc.

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Crescent Plates
Crescent Rivets
Crescent Rivet Extractors

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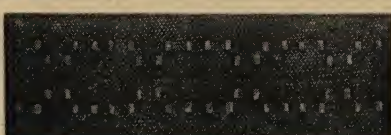
A Crescent joint is permanent for the life of the belt. It cannot wear. It does not put any undue strain upon the belt.



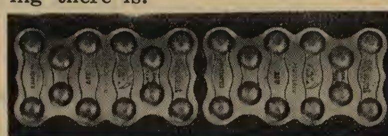
Pulley Side of Crescent Joint.

The clinch of Crescent Rivets grips the lengthwise fibres and sinks into the belt surface.

The cost is but a fraction of the usual endless method with additional savings of time, labor, delay and preservation of belting.

Crescent Belt Fasteners are universally recommended by belting manufacturers.

Shortening is easily and quickly effected so the belt can be kept at proper working tension at all times. This is accomplished by removing the Crescent rivets from one side of the Crescent joint (the Crescent rivet extractor is a convenient tool for this use). Then the slack is cut off and the belt is rejoined with a row of new Crescent rivets—the work of a moment. Crescent plates are not subject to wear, and can be used over and over again, making this unquestionably the most economical belt joining there is.



Outside of Crescent Joint.
Crescent Plates distribute the strain evenly and equally across the entire width of the belt. No metal wears against pulleys.

Made in sizes covering every condition of work and used on every kind and make of belting of any length, width and thickness.

APPLICATION

After cutting the belt square, attach the Crescent plates to one end, driving the Crescent rivets with a hammer. Bring up the other end and drive the remaining Crescent rivets. Then turn over and pound down the clinch of the Crescent rivets. That is all. In close places, the Crescent rivets may be driven directly against the face of a steel pulley, the shafting or a block of metal and they will clinch themselves.

SIZES

As this is a mechanical product it is important the correct sizes be employed. Data sheets and illustrations giving full information gladly sent on request.

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Our Service Engineers will help you solve your belting troubles if you will advise your operating conditions in full. You are placed under no obligation by writing or consulting them. Write for name of your nearest dealer.

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Goodrich is one of the nation's pioneers in the manufacture of conveyor belts. Made of the highest quality materials, Goodrich Conveyor Belts are ably equipped for the wrack and tear of transporting abrasive materials. They are particularly noted for the delivery of big tonnages at low cost. Space does not permit the detailing of the many structural advantages of Goodrich conveyor belts, nor the long list of users—but these are available on request.

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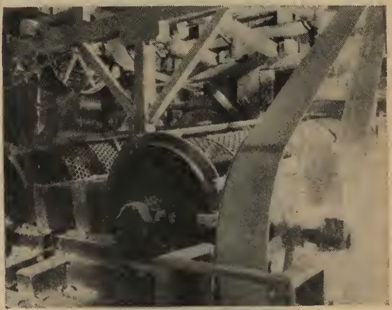
Goodrich Elevator Belts have kept steady pace with the improvements in Goodrich conveyors and are equally conspicuous for service and quality. We make them for wet and dry service, for light and for heavy duty work.



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V-B belting is made from extra heavy duck impregnated with a solution of pure balata gum, making the belt the strongest belt on the market for transmission, conveying and elevating purposes.

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Specify "Ampere," the Red Belt With the Black Edges, for Satisfactory All Round Service.

"VICTOR" Balata Cold Water Valves

"Victor" balata valves, perfectly seating, quiet and smooth working, non-deteriorating. Valves made from absolutely new material, built up ply upon ply. Victor Balata Valves will withstand grit or sand to a greater extent than any other valve.

WRITE FOR OUR BOOKLET "HOW TO FIGURE BELTS"—Yours for the asking.

R. H. BEAUMONT CO.

324 Arch Street, PHILADELPHIA, PA.

BRANCH OFFICES:

GREENVILLE, S. C. PITTSBURGH MINNEAPOLIS CLEVELAND
NEW YORK BOSTON DETROIT CHICAGO

PRODUCTS

Bin and Bunker Gates; Beaumont Skip Hoists for Bulk Materials; Cable Drag Scrapers for Ground Storage; Weighing Larries; Screens; Crushers; Feeders; Elevators; Conveyors; Steel and Concrete Bunkers; Track Hoppers; Automatic Loaders.

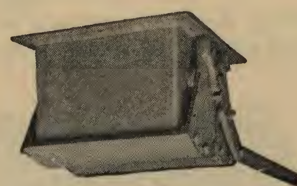
BEAUMONT BIN AND BUNKER GATES

These gates which we have adopted as standard, have been developed through 25 years of study and experience and may be safely used without fear of future trouble. The essential features of Beaumont gates are:

1. Ample leverage.
2. Counterweight on large gates.
3. Non-binding.
4. Normally closed.
5. Non-leaking.
6. Not closed or opened by gravity.

Either Beaumont Simplex or Beaumont Duplex Gates are well adapted to sand, gravel and crushed stone bins. Their ease of operation insures prompt loading and freedom from operating troubles. They may be installed to meet special conditions in operating arrangement. Stock sizes are 12″x12″ to 24″x24″.

We also manufacture Wall Type Slide Gates, Rock and Pinion Slide Gates and Geared Undercut Pivoted Gates.



Beaumont Duplex Gate.

Beaumont Simplex Gate.

Our experience is at your disposal and we are always ready to suggest the proper gate for any service.

Send for Catalogue 43.

BEAUMONT SKIP HOIST

The Beaumont Skip Hoist will handle any bulk material in lump, crushed, granulated or pulverized form. It is not affected by grit, heat or water. It consists of only a bucket, a cable and a winding machine.

The entire operation of the Beaumont Skip Hoist is automatic. Material is dumped into a loading hopper from which it is automatically loaded into the skip bucket. The bucket ascends, discharges, reverses, descends and is reloaded.

Send for Catalogue 50.

MULLINS BODY CORPORATION

Successors to W. J. Clark Co.

106 East Mill St., SALEM, OHIO

Elevator SALEM The Genuine Buckets

Products

SALEM Elevator Buckets — send for catalog and complete price list.
Sheet Metal Work of all kinds to order—Send Blue Prints or sketch for quotation.

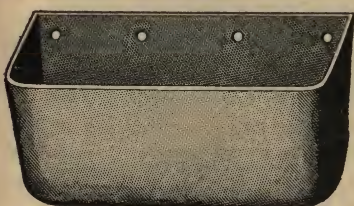


Fig. 668 "Salem" — A heavy duty steel bucket. Rounded contour throughout insures prompt, clean delivery. Suitable for Ores, Coal, Broken Stone, and similar heavy substances.

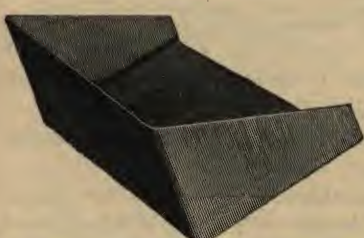


Fig. 131 Square Heel Shelf Bucket. Especially adapted for handling damp materials.

Fig. 1076 Open End Flat Bottom Shelf Bucket—For handling wet, sticky, substances which tend to pack in other styles of buckets.

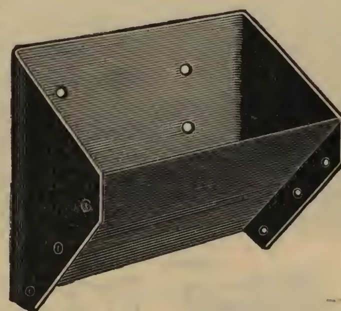


Fig. 1124 Continuous Type Bucket with straight trough front. Pours its load instead of throwing it.

Fig. 133 Acute Heel Shelf Bucket with beveled end. For handling sand, gravel, stone, coal, etc.

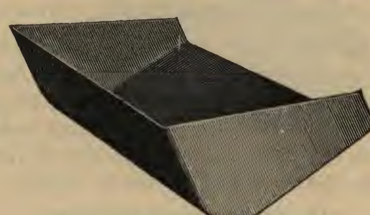


Fig. 132 Round Heel Shelf Bucket. Especially adapted for handling damp materials.

Mullins complete line of Elevator Buckets is unsurpassed in strength, durability, and quality of workmanship. A complete stock of standard sizes and gauges and our ability to furnish buckets made up in accordance with your specifications enables us to offer excellent service on whatever your requirements may be.

W. N. BEST FURNACE & BURNER CORP.

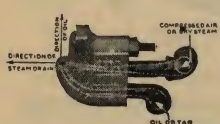
11 Broadway, NEW YORK.

PRODUCTS

W. N. Best Calorex Oil Burners and Oil Regulating Cocks for Locomotive, Marine and Stationary Boilers. Also Furnaces and Various Types of Kilns.

Designs supplied for changing coal-fired furnaces to oil-fired, for the remodeling of existing oil-fired furnaces, and for the construction of all forms of furnaces for heating and heat-treatment of metals

W. N. BEST "CALOREX" BURNER UNMOUNTED



The Air or Steam meets the oil at right angles, thus thoroughly atomizing the oil Externally, which prevents clogging or carbonizing, the burner always being kept clean. By releasing Nut of Atomizer any obstruction that might find its way through the atomizer line is blown out.

Air or dry steam from 15 pounds up can be used to atomize the oil. Burner being in form of a syphon requires but low oil pressure. Not over 10 pounds in boilers, kilns and furnaces.

Burners can be fitted to throw either a long narrow flame, or a fan-shaped flame 9 feet wide, thus doing away with the necessity of using more than one burner to any fire-box or furnace that is 9 feet or less in width.

"CALOREX" LOCOMOTIVE BURNER

Being pioneers in the development of oil burning equipment for locomotives in the United States, we have overcome the many difficulties incident to the service, and as a result we have hundreds of locomotives equipped, of all sizes, and used in all kinds of service.

The advantages of our system are as follows:

The burner thoroughly atomizes any gravity of oil.

It can be operated at maximum or minimum capacity at will of the fireman.

The burner has a syphoning action, therefore no air pressure is required on the oil in supply tank on the locomotive tender.

The oil orifice is below the steam orifice, therefore burner does not carbonize.

By means of an inverted arch the air required for combustion is admitted in proper quantities requisite for the demands of grades, etc.

There is no injury to flues or fire-box.

As there is no smoke or sparks, the danger of setting fire to forest, buildings, etc., is eliminated.

"CALOREX" LOCOMOTIVE OIL REGULATING COCK

The fuel enters through a V-shape, knife-edge orifice in the plug and passes out through a very much larger opening.

"CALOREX" FIREMAN'S REGULATING QUADRANT

The quadrant is attached by a rod to the oil regulating cock and allows for perfect control of fire necessary for speed, grades or drifting down hills.

THE LAKEWOOD ENGINEERING CO.

CLEVELAND, OHIO

PRODUCTS

Dump Cars, for hand and locomotive haulage. (Ask for specification sheets No. 241-A and No. 241-B), Quarry Cars, Turntables, Portable Track, Clam Shell Buckets, and Storage Battery Trucks.

SERVICE

The Lakewood Engineering Company has one of the largest plants in the country specializing in industrial and narrow gauge railway cars, and is in position to give its customers the benefit of long experience in designing and building all types of standard and special cars.

Due to our large car shop, we can give prompt attention to all orders.

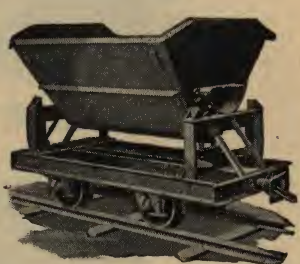
We quote on narrow gauge cars built either to our own or customers' designs to meet special conditions.

Our Engineering Department is at your service.

QUARRY CARS

Lakewood Quarry Cars are made in end dump, bottom dump, gable bottom dump, side and "V" dump types.

When inquiring, please state method of loading cars—that is, whether by hand or steam shovel, how they are to be hauled—that is, by cable, hand, or locomotive, the track gauge and quantity of cars required. Also advise whether or not there are any limiting dimensions for clearances.



DUMP CARS

Lakewood Dump Cars, used as standard by many limestone quarries, are well-known for their high-grade Hyatt roller bearings, heat treated axles and spring draft rigging.

EASTON CAR & CONSTRUCTION CO.

Main Office & Works at

29 Holley Street, EASTON, PENNSYLVANIA

BRANCH OFFICES at

New York Philadelphia Pittsburgh St. Louis Norfolk Savannah
Birmingham Salt Lake City Los Angeles

EASTON QUARRY PRODUCTS

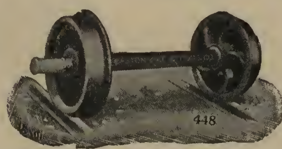


Fig. 448—Wheels and Axles for any design and for all gauges.

Fig. 80—Portable Track and Switches; all gauges and rail weights.

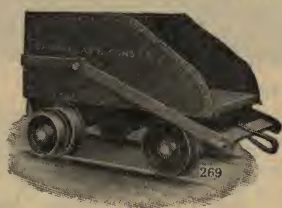


Fig. 269—All-steel Skip Cars of various designs.

Fig. 249—Automatic Door Trip Gable Bottom Car.

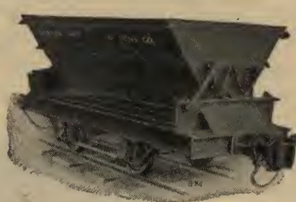


Fig. 974—Special Rocker Dump Car for locomotive traction.

Fig. 184—Special design of Quarry Car with Automatic End Door.

Fig. E-329-H—Easton Scoop Body in use in a quarry. The low hand-loading height is a great advantage.

EASTON CAR & CONSTRUCTION CO.

STANDARD ROCKER DUMP CARS

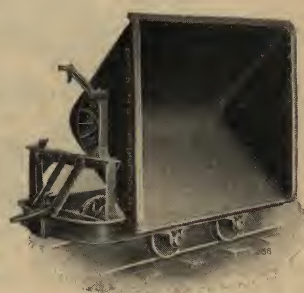
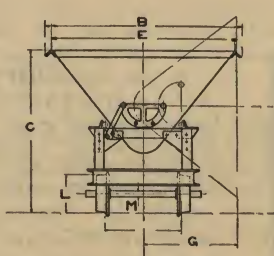
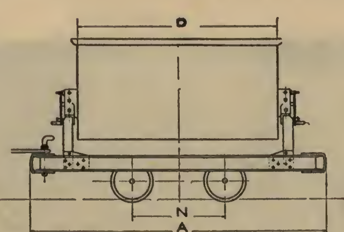


Fig. 255 Fig. 256

Easton Rocker Dump Car in upright position and in fully dumped position.

Easton Standard Rocker Dump Cars meet the Quarryman's requirements, not only because of sturdy construction, good material, and first class workmanship—for these you have a right to expect—but also because they embody a wide experience in actual quarry operation, a knowledge of just what the Quarryman is up against, what he has to do and how he likes to do it. Carefully balanced, easy to dump, discharges clear of the wheels, equally efficient for handling sand, gravel, stone, and other rock and quarry products.





Code Word	Cap. ft.	Track Gauge	Over All Dimensions A	Over All Dimensions B	Over All Dimensions C	Body Dim. D	Body Dim. E	G	L	M	N	Plates Side	Plates End	Wgt. lbs.
Ribbenland....	18	24"	6'-7"	4'- 3"	3' 8"	4'-0"	4'-0"	1'-10½"	12"	1¾"	2'-0"	⅛"	⅛"	900
Ribbestuk......	27	24"	7'-3"	4'- 5"	3' 9½"	4'-9"	4 -2"	1'-11½"	12"	1¾"	2'-0"	⅛"	⅛"	1000
Ribbonism	40	24"	8'-0"	5'- 4"	4 6¾"	5'-5"	5'-0"	2'- 3½"	14"	2"	2'-6"	⅛"	3/16"	1325
Ribeavate......	27	30"	7'-4"	4' 5"	3'-11"	4'-9"	4'-2"	2'- 2"	12"	1¾"	2'-4"	⅛"	⅛"	1050
Ribecco........	40	30"	8'-1"	5' 4"	4'- 9"	5'-5"	5'-0"	2' 6"	14"	2"	2'-6"	⅛"	3/16"	1425
Ribollisco	54	30"	8'-8"	5'-10"	4' 11"	6'-0"	5'-6"	2' 6½"	14"	2¼"	2'-6"	3/16"	¼"	1675
Ribucammo	40	36"	8'-1"	5 4"	4 9"	5'-5"	5'-0"	2' 8"	14"	2"	2'-6"	⅛"	3/16"	1520
Riburlato	54	36"	8'-8"	5' 10"	5' 0"	6'-0"	5'-6"	2' 8½"	14"	2¼"	2'-6"	3/16"	¼"	1770

NOTE.—Capacities level full, weights and dimensions approximate only and not binding upon us. End braces on cars forty cubic feet and over

2181-E

SANFORD-DAY IRON WORKS

KNOXVILLE, TENN.

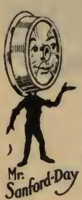
PRODUCTS

Car Wheels and Cars of All Kinds

IF—"THEY'RE WORTH THEIR WEIGHT IN GOLD"

To Him,

What Are They Worth to You?



One of the very first quarry men who purchased S. & D. GRIFFITH AUTOMATIC DROP BOTTOM CARS says: "They're worth their weight in gold."

No wonder—just think of dumping your material entirely automatically, without uncoupling or handling cars at all. And think of the extra capacity without increasing height of car above rail.

S. & D. GRIFFITH AUTOMATIC DROP BOTTOM CARS are made to your specifications and to suit your conditions. They are all steel, all wood or composite as you may prefer — and, remember, they are equipped with Whitney Wonder roller bearing wheels and guaranteed bearings.

Prices and literature on request.

INLAND ENGINEERING CO.

2 N. Michigan Ave., CHICAGO, ILL.

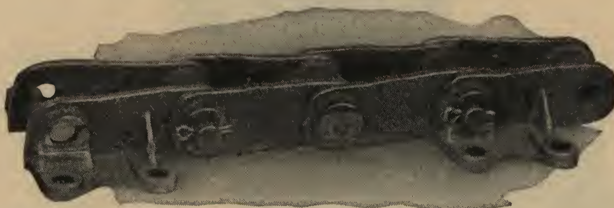
PRODUCTS

Manganese Steel Castings of all kinds Chrome and Special Alloy Steel Castings of all kinds. Supplied rough or finished ready for service

USES

The list which follows is by no means complete but will show in a general way the kind of work we are well equipped to handle.

Pulverizer Parts	Elevator Buckets
Hammers	Steam Shovel Repairs
Crusher Parts	Dipper Teeth
Concaves	Dippers and Buckets
Crusher Heads	Lips
Roll Shells	Gears and Pinions
Jaw Plates	Sheaves
Chain	Screen Plates
Sprockets and Idlers	Chute Plates



More attention is each year being directed toward the prevention of losses caused by shut-downs in the plant. It is acknowledged that the trouble is usually caused by the rapid wearing out or breaking of machinery parts. During the busy season when the plant must operate continuously at its maximum capacity, production is obviously paramount and it is then especially that the wisdom of having installed parts made of INCO Manganese Steel or of INCO Chrome Steel becomes most evident.

INCO Manganese Steel Castings

An interesting and important fact concerning Manganese Steel is that it cannot be drilled nor tooled in a commercially satisfactory way which fact demonstrates the unusual toughness of this strong, durable metal. Holes are usually provided by setting cores in the mould before pouring the molten steel. These holes must be clean and smooth and must be located quite accurately. By the use of modern grinding machinery we are able to finish the surfaces requiring accurate dimensions.

Despite the fact that INCO Manganese Steel resists tooling so successfully, it is not brittle but is extremely tough and is therefore highly recommended for castings that are subjected to severe shock or strain.

INCO Chrome Steel Castings

Speaking generally, INCO Chrome Steel will give excellent service when wear alone is the important factor, but it should not be used where the shock or strain is unusually severe. It may be readily drilled and otherwise machined, and is usually manufactured and sold at prices somewhat lower than those realized for parts of a similar or identical design when made of Manganese Steel. It is considered the most economical to use for certain purposes.

Other INCO Alloy Steels

Your particular needs may require the use of an Alloy Steel possessing qualities that are not found in either Manganese or Chrome Steel, and in order to serve you to the best advantage we are willing to study your problems and to assist you in obtaining the metal best suited to meet the requirements of the particular installation.

MOORE & MOORE, INC.

READING, PENNA.

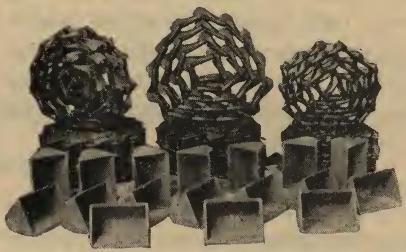
PRODUCTS

M. & M. Electric Manganese Steel Parts.

M. & M. MANGANESE STEEL

The use of Manganese steel for the wearing parts of crushing, conveying, shoveling and dredging equipment has solved an economic problem for the operator.

The high standard of M. & M. Electric Manganese steel, sold at a price based upon cost has further placed in the operator's hands the means of obtaining long and continuous equipment service at a low cost.



M. & M. MANGANESE CHAIN & BUCKETS

A large stock of electric manganese steel chain together with their attachments is always carried in stock. Every link is thoroughly tested and guaranteed. Conveyor buckets can be furnished promptly in both manganese. steel or plate steel made to any specification.

M. & M. MANGANESE REPAIRS

We specialize in electric manganese repair parts which are noted throughout for their wear resisting qualities. In view of the fact that the electric process gives us absolute control of the percentage of manganese which determines this quality.

The above concaves and mantles show some of these parts.

Manganese Jaw Plates, Cheek Plates, Toggles, Toggle Bearings, Gears, Pinions, etc., are produced by the electric process. Sample test bars will be furnished upon request.

Quality and Service is our Aim and great care is exercised in maintaining this policy.

AMERICAN MANGANESE STEEL COMPANY

GENERAL SALES OFFICES, 387 E. 14TH ST., CHICAGO HEIGHTS, ILL.

PLANTS: CHICAGO HEIGHTS, ILL. NEW CASTLE, DEL. OAKLAND, CAL.

AMSCO

PRODUCTS

Amsco Manganese Steel Chain of standard and special designs. Amsco Manganese steel sprockets, traction wheels, elevator buckets. Write for our Catalogue.

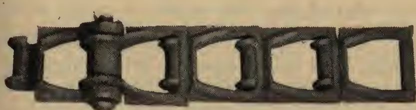
Amsco Manganese Pumps and Parts catalogued on page 291.

Amsco Manganese Dippers, dipper-fronts, and teeth, catalogued on page 231.

AMSCO CHAINS

Amsco Manganese Steel Chains scarcely need an introduction. The wearing quality of Amsco Manganese steel is well known and Amsco chains have proved their economy in numerous types of installations. Chain of standard design is carried in stock. Manufacturing facilities are such that special designs can be handled with dispatch.

EWART DETACHABLE LINK CHAIN



is standard in design—interchangeable with standard chain links of other manufacture and works upon sprockets corresponding in number. We can supply standard attachments or any special attachments desired.

COMBINATION TYPE

is of standard design and works on sprockets as follows: Chain No. 188—sprocket 75, 78, 88. No. 131—sprocket 103, No. 102—sprocket 102. No. 111—sprocket 108. No. 110 or 141—sprocket 110. No. 132—sprocket 122.

Posselt Combination type differs from standard combination type by having a greater bearing surface for the pin in the side links through means of projections around the pin holes. This is an excellent type of chain in the handling of hot clinker direct from the kilns.

700 AND 800 SERIES

These chains correspond to the Ley-bushed and Pintle types. Links are made in one piece and without bushing, which is unnecessary, due to the wearing qualities of Manganese Steel.

The 800 Series chain operates only on sprockets designed for Manganese chain with the exception of No. 846, which runs on sprockets for Ley-bushed or Peerless chain of same number.

ROLLER TYPES

We manufacture all types of Roller Chain that can be cast in Manganese Steel. In some cases it has been found advisable to slightly modify the design. The essential dimensions, however, are adhered to so that standard sprockets may be used.

SAND DREDGE TYPE

Designed to overcome the difficuties encountered in sand and gravel dredge work, it performs the service intended in a most satisfactory method. Standard and special designs are furnished.

GRAB BUCKET TYPE

Opening and closing chains for Grab Buckets give added life when constructed of Amsco Manganese Steel. Both links and pins are made of Amsco.

SIMPLEX RIVETLESS TYPE

Simplex Rivetless Chain is a heavy duty detachable chain, with links and pins easily assembled or detached without tools. It is furnished with either center drive pins or outside drive pins. We recommend the use of outside drive pins as the strain is distributed evenly upon the pins and most of the wear taken from the links. It is exceptionally strong and the combined features of simplicity, strength and the unequaled wearing qualities of Manganese steel should command the favorable attention of users of elevating or conveying chain.

HOWE CHAIN COMPANY

MUSKEGON, MICHIGAN

NEW YORK OFFICE: 30 CHURCH STREET
CHICAGO OFFICE: MONADNOCK BLOCK

PRODUCTS

Chains for Elevating, Conveying and Power Transmission, Malleable Iron Elevator Buckets, Sprocket and Traction Wheels.

The Howe Chain Company specializes in the manufacture of malleable iron and steel chains for elevating, conveying and power transmission, malleable iron elevator buckets and sprocket and traction wheels.

Our products are standard in every way, and will interchange readily with all standard makes.

Large stocks of all the standard sizes and styles of chains and buckets are maintained at our plant. Our service is unusually prompt.

The quality and durability of our products is assured by careful manufacturing practices and years of experience in this field.

Catalog No. 121 fully describes our complete line of chains, elevator buckets and sprocket and traction wheels. Ask for your copy.

S. G. TAYLOR CHAIN COMPANY

138 So. Dearborn St., CHICAGO, ILL.

This reproduction of 1¼" iron illustrates a cross section of the bar etched so as to show the method of piling the iron used in the manufacture of our Taylor Mesaba Steam Shovel Chain. This iron is fibrous throughout the entire length of the bar and to insure this quality it is triple rerolled and refined to our order. The analysis must show it to be made from muck bar iron free from steel and scrap.

As iron and steel require different heats for welding, iron containing steel or scrap cannot be welded as thoroughly as this fibrous muck bar iron which is used exclusively in the manufacture of our Taylor Mesaba Chain.

The method of piling shown in the illustration has been used by the United States Navy and proved to produce an iron which reduces the possibility of splitting to a minimum.

For the severe service demanded, we recommend our Taylor Mesaba Chain which has been tried and proven.

For dredges, drag lines, etc., our Taylor Made Dredge Chain is very satisfactory, the difference between this grade and the Mesaba quality is in the material used.

Our chains are welded by master craftsmen and proof tested, after which each link is inspected before shipment is made.

Sizes carried in stock for all makes of shovels: 5/8, ¾, 7/8, 1, 1⅛, 1¼, 1 3/8, 1½, 1 5/8 inches.

PRODUCTS

Taylor Mesaba Steam Shovel Chain, Taylor Made Dredge Chain, Proof Coil, BB and BBB Steel Chain, Steel Loading and Logging Chain, Sprocket Chain, Railroad Brake and Switch Chains.

Specify

TAYLOR MESABA

Steam Shovel Chain
Manufactured by
S. G. TAYLOR CHAIN COMPANY
138 S. Dearborn St., Chicago, Ill.

Send for latest Catalog

Carried in Stock by
MARSHALL-WELLS CO.
Duluth, Minn.

UNITED STATES CHAIN & FORGING CO.

UNION ARCADE BUILDING, PITTSBURGH, PA.

Plants at York and McKees Rocks, Pa.—Columbus and Marietta, O.—Huntington, W. Va.
Branch Sales Offices:
Chicago, Ill., First Natl. Bank Bldg. New York, N. Y., 30 Church Street.

PRODUCTS

Old Reliable "XX" Dredge Chain, made of Checker-Board Iron.

Characteristics of Old Reliable "XX" Dredge Chain:

Dependable uniformity.

Will withstand abrasion to a very marked degree, making it especially desirable for use on steam shovels and dredges.

Is hard and tough with long wearing qualities.

Is sufficiently ductile to withstand sudden and severe shocks without crystalizing.

High tensile strength; will carry the heavy loads subjected to when used in connection with cranes, hoists, slings, wrecking cars, etc., with the highest factor of safety.

WORKMANSHIP

The welding of our "XX" Dredge Chain is entrusted to our most skilled workmen, who have shown exceptional proficiency, men with many years of experience and of proven ability.

PROOF TESTING

Experience has proved that "XX" Dredge Chain should not be proof tested to strains higher than shown in the table in our catalogue and pamphlets. Proof testing to higher strains will depreciate the elasticity, shock and fatigue resisting qualities of the chain. Under no circumstances should chain be proof tested up to the yield point of the material. To do so is very detrimental.

INSPECTION

Thoroughly trained inspectors are constantly in attendance; inspecting the iron, the working details while the chain is being made and finally the finished chain. The chain is proof tested to the regular proof strain for each size and inspected link by link before shipment.

IDENTIFICATION

Stamped "XX" every six feet.

RECOMMEINDED FOR USE ON

Steam shovels, dredges, cranes, derricks, sling chains, wrecking car units, ship cargo chains, steering gear chains, ship salvaging chains, pocket wheels, and all uses where the chain will be subjected to high tensile strains, severe shocks, abrasion, etc., and especially where lives and expensive machinery are at risk.

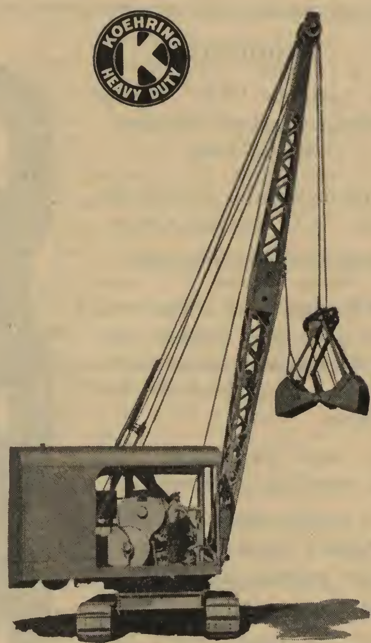
KOEHRING COMPANY

MILWAUKEE, WISCONSIN

SALES OFFICES IN ALL PRINCIPAL CITIES

PRODUCTS

Gasoline Cranes, Drag Lines, Clamshells, Power Shovels. Also Concrete Mixers, Bar Benders and Bar Cutters.



The Koehring Crane Excavator with clamshell bucket is a powerful, staunchly built, dependable machine, which is easily convertible into either a dragline or power shovel.

Mounted on Koehring full length multiplanes, with a full circle swing turntable, and equipped with a powerful, four cylinder gasoline engine, it is adapted for all possible uses of a crane or excavator.

It is built for sturdy work. Ninety-five per cent of the weight of all castings used are of high carbon steel. And it has that **Heavy Duty** construction characteristic of all Koehring products, which provides **dependable,** steady service and longest possible life.

When working with clamshell bucket in stock piles or other restricted quarters, it is not necessary to travel back and forth with the Koehring. The loaded bucket can be boomed in or out as often as necessary to reach materials without moving the crane.

CAPACITIES

No. 1—7 tons at 12′ radius. ¾ yard bucket at 25′ radius.

No. 2—12 tons at 12′ radius. 1 yard bucket at 35′ radius.

No. 3—20 tons at 12′ radius. ½ yard bucket at 40′ radius.

Equipment includes four cylinder gasoline engine; full length Koehring designed multiplanes, with positive steering arrangement; forward and reverse traction. Extras obtainable include independent lighting system for night operation; air or electric starter, and either canopy top with drop curtains, half cab, or enclosed.

Send for catalogue Q1.

ALLIS-CHALMERS MFG. CO

MILWAUKEE, WIS.

DISTRICT OFFICES

Atlanta	Cleveland	Los Angeles	Portland
Baltimore	Dallas	Milwaukee	St. Louis
Birmingham	Denver	Minneapolis	Salt Lake City
Boston	Detroit	New Orleans	San Francisco
Buffalo	Duluth	New York	Seattle
Charlotte	Indianapolis	Philadelphia	Toledo
Chicago	Kansas City	Pittsburgh	Wilkes-Barre
Cincinnati	Lakeland, Fla.		

FOREIGN DISTRICT OFFICES:

London, England, 728 Salisbury House, London Wall, E. C. 2.—Paris, France, 3 rue Taitbout—Santiago, Chile, Edificio Ariztia, Casilla 2653.
Canadian Representatives—Canadian Allis-Chalmers, Ltd., Toronto, Ont.

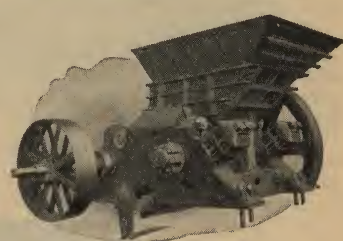
PRODUCTS

Crushers, Screens, Etc.

Over forty years' experience and contact with crushing and screening rock and gravel, are accumulated in our latest designs of crushers and screens.

We have developed in all sizes the latest gyratory crushers—the Gates Style "N" Machine.

The "Fairmount" Crusher is intended to crush limestone, dolomite, phosphate rock, magnesite, and other less tenacious trap rock. It is not suitable for or recommended for granite trap rock, or other igneous rock.



GATES TYPE SCREENS

The durability, simplicity and efficiency of the Gates Patented All-Iron Frame Screens is unequalled by any other screen on the market.

Gates Screens are built in numerous sizes, ranging from 24-inch diameter by 8 feet long, to 72-inch diameter by 24 feet long. Open End Scalping Screens of the Cylindrical type are built in sizes ranging from 48-inch to 72-inch diameter.

ENGINEERING SERVICE

Our engineers are at your service to analyse your conditions and to design and install a complete, highly efficient crushing and screening plant of our own manufacture.

OTHER PRODUCTS

Crushers, Pan and Bucket Elevators, Skips, Hoists, Dryers, Revolving and Shaking Screens, Centrifugal Pumps and Pumping Units, Motors, Air Compressor Equipment, Power Transmission Machinery, Perforated Metal, Complete Crushing Plants, Cement Making Machinery, Mining and Metallurgical Machinery, Electrical Machinery, Steam Turbines, Steam Engines, Condensers, Gas and Oil Engines, Hydraulic Turbines, Pumping Engines, Flour Mill and Saw Mill Machinery, Timber Preserving Machinery, etc.

AMERICAN PULVERIZER CO.

18th and Austin Streets, ST. LOUIS, MO.

PRODUCTS

Crushers and Pulverizers for all refractory materials.

ADAPTABILITY

These machines will crush and pulverize to any desired fineness, shale, limestone, gypsum, burnt lime, etc.

DESCRIPTION

Our machines are built on the ring principle. The centrifugal force as utilized through the ring is heretofore unemployed in any Rotary Pulverizer. The ring affords a flexible adjustment within itself, same being controlled by its centrifugal force, hence we avoid fixed togget work adjustments which invariably rust, clog and become useless.

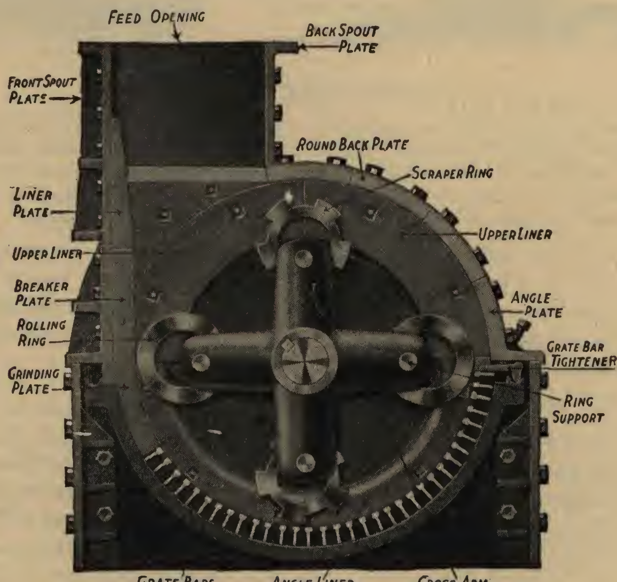
The material enters the pulverizer on top, allowing the material to fall direct upon and be struck by the rings while in suspension. This shatters and distributes the material before reaching the breaker plate. It then falls to the concave grinding plate and grate bars for final pulverization. The degree of fineness is regulated by the openings between the grate bars, —the capacity is governed likewise.

ADVANTAGES

Only 600 R. P. M. are required to operate the American Ring Pulverizer effectively. Due to the centrifugal force of the rings, a minimum of power is consumed, yet high capacity is obtained. Operation is easy and a minimum of space is required. Foreign material cannot damage machine.

ADDITIONAL INFORMATION

Always specify material to be ground and capacity and fineness required. If possible, send us samples of crude material and finished product required. We maintain an engineering department which is available for our prospective customers.



Cross Section of American Ring Pulverizer.

BRADLEY PULVERIZER CO.

WORKS: ALLENTOWN, PA.

BOSTON, MASS. LONDON, ENG.

PRODUCTS

Pulverizing Machinery
Air Separating Machinery
Cement Mill Machinery
Agricultural Limestone Pulverizers
Phosphate Rock Pulverizers

A complete line of pulverizers for reducing all refractory materials 20 to 200 mesh—especially adapted for Agricultural Limestone Plants—Cement Plants—Fertilizer Wks., etc.

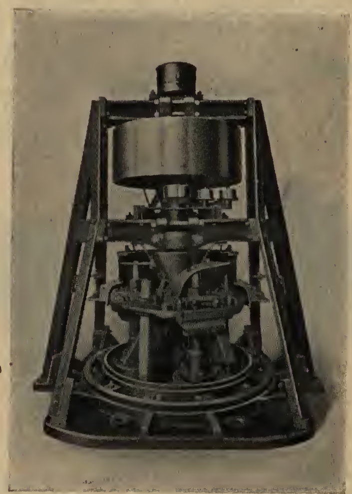
Sole Manufacturers of

The GRIFFIN MILL

The BRADLEY 3 ROLL MILL

The BRADLEY HERCULES MILL

The BRADLEY SUPER SEPARATOR



Bradley 3 Roll Mill

Bradley Hercules Mill

Our Machinery is standard equipment for reduction of Agricultural Limestone—Asphalt Filler — Cement Materials — Coal—Phosphate Rock—Refractory Clays, etc.

Descriptive catalogues and complete information gladly furnished to prospective users.

A Pulverizing Mill for most every purpose.

Specialists in designing efficient grinding and pulverizing plants since 1889.

DIXIE MACHINERY MFG. CO.

3661 Market St., ST. LOUIS, MO.

PRODUCTS

Dixie Hammer Type Crushers and Pulverizers

Repairs for all makes of hammer crushers and pulverizers.

The Dixie Swing Hammer Crushers and Pulverizers are now recognized and accepted as standard for a wide range of crushing and pulverizing.

The Dixie Swing Hammer Crushers and Pulverizers are built in sizes to meet requirements of any tonnage per hour.

The Dixie Swing Hammer Crusher and Pulverizer is made up to a very high standard and guaranteed to operate at less cost and lower upkeep cost per ton. This is due to the many later and adjustable features. The Dixie is also built 30 to 50% stronger.

We have the advantage of 25 years' experience in building these swing hammer crushers and pulverizers, and have had experience with about every kind of material that can be reduced, which experience is of great importance to the prospective customer who wishes concrete data before purchasing.

We also have at the head of our engineering department the man that designed the first hammer machine, and who has in the last 25 years made more improvements that has made the hammer crusher what it is today. Is this experience worth the chance to solve your crushing and pulverizing problems?

Let us solve your crushing and pulverizing problems. To receive a prompt reply and a thorough analysis of your problems, address your inquiries to Dept. 39.

GRUENDLER PATENT CRUSHER AND PULVERIZER COMPANY

953 N. Main Street, ST. LOUIS, MO.

Representatives:

CHICAGO—Milling Equipt. Co., 9 S. Clinton St.
NEW YORK—Max Moser, 1669 Broadway.
SAN FRANCISCO—Oriental Supply Co., 688 Howard St.
LOS ANGELES—Geo. B. Wilson Co., 308 E. 3rd St.
DALLAS—F. T. Morrissey, 305 Slaughter Bldg.
SALEM, VA.—Salem Foundry & Machine Co.
SCRANTON—Scranton Engineering Co.
TAMPA—E. W. Price, 1317 S. Howard St.
SHREVEPORT—Dixie Machinery Co.

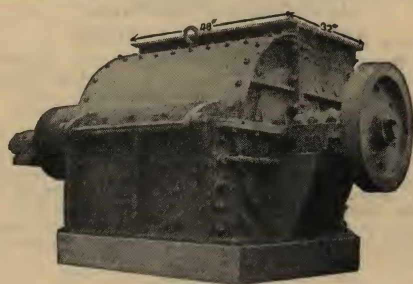
GRUENDLER
CRUSHERS · PULVERIZERS · GRINDERS

PRODUCTS

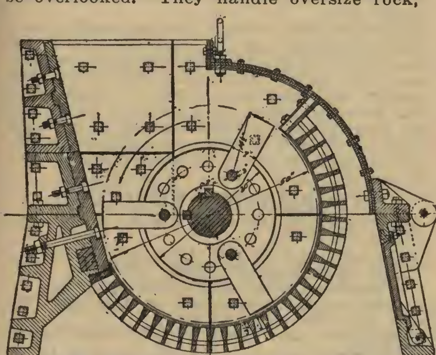
Jaw and Gyratory Crushers, Swing-Hammer Pulverizers, Revolving Screens, Elevators, Complete Crushing Plants, Washing, Screening and Storage Plants and Complete Road Building Equipment

ADVANTAGES

Gruendler Crushers and Pulverizers are specially constructed to stand heavy stresses and strains. Ballbearing or ring-oiling throughout, they start under full load—can't be overlooked. They handle oversize rock, shale, or clay—**just as it comes from the quarry**, reducing it to a product passing ⅛-in. grate bar, **in one operation**, and at a big saving in horsepower. A size for every need, ranging from 3 to 5,000 tons daily capacity. Having greater capacity of most uniform product per H. P. than dry or wet pans or any other type of pulverizers, one Gruendler often replaces as many as three dry pans, increasing output and lowering costs. Fewer parts and fool-proof construction insure minimum up-keep.



Heavy Type Gruendler Crusher.



Cross Section—200 Ton Per Hour Crusher.

GUARANTEE

Every machine is absolutely guaranteed for two years against all defects in workmanship and material. Write for details of FREE TRIAL offer.

Specifications—Gruendler Swing-Hammer Crushers.

No.	Size	Approx. H. P.	Approx. Weight, Pounds	Speed, R. P. M.	Size Pulley	Approx. Capacity Per Hour. ⅛″ Bar Opening
X	18″	7	1,200	1200 to 1500	8x 7″	1 to 1½ Tons
XB	18″	10	1,350	1200 to 1500	9x 8″	2 to 3 "
XXB	24″	15	2,700	1200	12x10″	4 "
XXC	24″	25	3,000	1200	14x12″	5 "
XXX	30″	30	4,500	1000 to 1200	16x12″	6 to 8 "
XXXD	30″	35	5,500	1000	16x12″	8 to 10 "
XXXX	36″	45	6,500	1000	16x14″	10 to 12 "
XXXXE	36″	65	7,500	1000	16x16″	15 "
XXXXF	42″	75	8,500	900	20x18″	20 "
XXXXG	42″	100	15,000	900	24x22″	30 "
XXXXH	42″	110	17,000	800	24x26″	40 "
XXXXI	42″	120	20,000	600 to 800	24x28″	60 to 70 "

Will Handle 48″ Rock in One Operation.

HARDINGE COMPANY

Incorporated

120 BROADWAY, NEW YORK, N. Y.

BRANCH OFFICES:

SALT LAKE CITY, UTAH,
NEWHOUSE BUILDING.

LONDON, ENGLAND,
11 SOUTHAMPTON ROW, W. C. 1.

WORKS: YORK, PENNA.

Manufacturers of Crushing, Grinding, and Pulverizing Equipment

PRODUCTS AND SERVICE

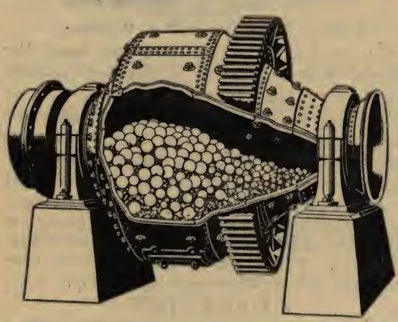
Manufacturers of Hardinge Conical Ball and Pebble Mills for pulverizing and grinding.

Engineers for the Erection and Design of Industrial Plants.

SIZES AND CAPACITIES

Hardinge Conical Ball and Pebble Mills are made in sizes from 24 in. in diameter to 10 ft. in diameter, with capacities ranging from a few pounds per hour to 50 tons an hour. Grinding is done wet or dry.

Ball mills are used to take a rock crusher product and grind to pass 20-, 40-, 80-, or 200-mesh. Pebble mills are used to take a ½-in. feed and grind to any fineness. The wear on lining and balls in the ball mill is surprisingly low. The pebbles in the pebble mill do not contaminate the material being ground.



How Balls Segregate During Operation of a Hardinge Conical Mill

MATERIALS GROUND

Materials being successfully ground in the Hardinge Mill are:

Talc	Barytes	Phosphate rock
Silica	Sulphur	Cement clinker
Glass	Feldspar	Fullers' earth
Clay	Graphite	Iron ores
Colors	Limestone	Graphite ores
Coal	Chemicals	Chrome ores
Coke	Brass ashes	Manganese ores
Mica	Iron borings	Tungsten ores

ACTION IN THE HARDINGE MILL

In the Hardinge Mill, due to the action of the cone, the coarse material on entering the machine gravitates to the point of largest diameter. Here it comes in contact with, and is broken by, the largest balls moving at the highest velocity and falling from the greatest height. As the particles are broken, they automatically work their way forward, being subjected to a gradually diminishing breaking and crushing effect as they decrease in size. The particles undergoing reduction reach the required degree of fineness and arrive at the discharge end of the mill at the same time.

Thus it is seen that this automatic classification, both of the material being reduced and of the grinding mediums, as well as their height of fall, proportions the energy expended or exerted in crushing to the work required. In this way, we obtain an ideal step or stage reduction in a single machine, which is conducive to a maximum crushing effect for a minimum expenditure of power.

INFORMATION REQUIRED

Character of material (send 2- or 3-oz. sample of feed).

Capacity required in tons per hour.

Size of feed to Hardinge mill.

Fineness of finished product desired.

Grinding to be done wet or dry (percentage of moisture in feed).

Machines now used to effect the same reduction.

CONICAL BALL MILL SPECIFICATIONS

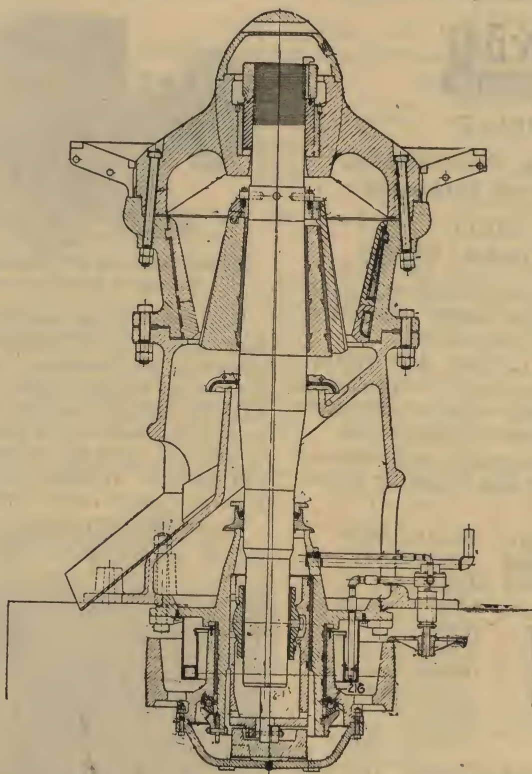
Size of Mill	Floor Space	Approximate Weights, Pounds: Mill	Lining	Ball Chg.	H.P. to Run	Size of Motor H.P.	Capacity in Tons Per Hour: 1½" to 8 mesh	1½" to 48 mesh	½" to 65 mesh	¼" to 200 mesh	Code Word
2' x 8"	3'x 5'	750	375	600	1	2	¼	⅛	1/6	1/10	Boluj
3' x 8"	5'x 7'	3800	1400	1000	5	7½	2/3	1/3	1/3	1/5	Bolus
4½'x16"	7'x10'	6600	4800	4500	18	25	2	1	1 1/3	¾	Bomdu
5' x22"	9'x10'	10200	7800	7500	30	35	3	2	2½	1½	Bonhu
6' x22"	10'x11'	12000	10000	12000	45	50	6	4	5	3	Boots
7' x22"	11'x12'	14000	14000	20000	70	75	10	7	8	5	Botun
7' x36"	11'x13'	15000	16300	27000	90	100	12	8	9½	6	Bounc
8' x22"	12'x14'	20300	17700	30000	100	100	14	9½	11	6½	Cabma
8' x36"	12'x14'	22000	19400	34000	135	150	18	14	16	11	Caciq
8' x48"	12'x15'	27400	22600	38000	170	175	24	19	21	15	Cactu
9' x48"	13'x16'	35000	30000	53000	230	250	33	26	29	25	Caddi
10' x48"	13'x16'	40000	35000	68000	300	350	45	35	38	..	Cadut

This capacity table must be considered as an approximation only, as every material varies in its resistance to grinding.

For complete specifications of both Conical Ball and Pebble Mills ask for our No. 13 catalog.

KENNEDY-VAN SAUN MFG. & ENGRG. CORP.

NEW YORK CITY 40 RUE DES MATHURINS, PARIS



K. V. S. PRODUCTS

Mining, Crushing, Cement, Elevating, Conveying, Screening and Pulverized Coal Equipment, Sand Washers and Classifiers.

KENNEDY GEARLESS CRUSHERS

We specialize in furnishing complete plants.

Note our Ball Bearing Gearless Crusher for preliminary crushing and for fine crushing. One machine capable of doing the work of three Geared Crushers.

They are noiseless, and take little power.

Cost of mainteance is cut more than 80%.

Our Air Swept Tube Mills and Ball Tube Mills for fine grinding and uniform products are not even approached by others. We lead. The others follow.

All made in our own shop, built and equipped for making this class of machinery by men who know how.

Our line is the largest and most modern in the world. We have the goods and the price. Give us your inquiries.

LEWISTOWN FDY. & MACHINE CO.

LEWISTOWN, PENN.

PRODUCTS

Blake Type Crushers, **Elevators,**

Dry Pans, **Conveyors,**

Driers.

Write for our catalogue.

Lewistown Standard Blake Type Crusher

SERVICE

Besides manufacturing a line of equipment for crushing, grinding, screening, washing, drying and elevating we also offer a complete engineering service in connection with the planning, designing and supervision of building silica sand plants.

CRUSHING AND GRINDING EQUIPMENT

Our Lewistown Standard Blake Type Crusher was designed particularly for use in accomplishing the primary reduction of silica rock to sand. A 20x12-inch crusher handles from 14 to 20 tons of material per day, about 3 inches and under.

Lewistown Blake Crushers work at a speed of 250 revolutions per minute and operate on an average of 15 horse power.

Lewistown 9-foot grinding pans are recommended for fine grinding in connection with Blake Type Crushers. They are designed to operate with this crusher.

NEW HOLLAND MACHINE COMPANY

100 Franklin St., NEW HOLLAND, PA.

PRODUCTS

Rock Crushers, Recrushing Rolls, Rock Pulverizers, Elevators and Conveyors, End Jolt Screens

The *New Holland* Rock Crushers are designed to crush all kinds of rock into all grades for road making and concrete work. They are furnished on skids or trucks ranging in capacity from one to ten tons per hour.

These crushers are especially well adapted for small quarries, concrete plants, contractors, towns, farms, land improvement companies, and for municipal work. On account of the low prices they are frequently used by manufacturers to crush old foundation, and other stone for concrete work, paving purposes, and making roads around their plants.

The *New Holland* Recrushing Rolls are designed for making finer grades than is possible to make with the jaw crusher. They can be used separately or with jaw crushers on skids or trucks. They will recrush all kinds of crushed rock, cinders, etc., for concrete building blocks, pipes, and fine concrete facing, as well as produce a uniform fine grade building and motor sand.

The *New Holland* Rock Pulverizers are made in different types and sizes, furnished separately or with crushers or with recrushing rolls.

The *New Holland* Elevators and conveyors are made in different styles, capacity and length. The *New Holland* Revolving Screens are made in two different sizes and different lengths with capacity from five to one-hundred tons per hour.

The *New Holland* End Jolt Screens are made in four different sizes, single multiples, and in tandem. These are especially designed for screening extra fine grades or material that is difficult to separate.

Full description and prices will be furnished upon request.

UNIVERSAL CRUSHER CO.

200 THIRD STREET, CEDAR RAPIDS, IOWA

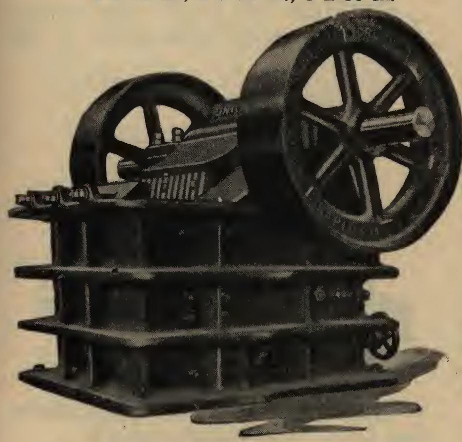
CRUSHERS FOR ALL PURPOSES

CONTRACTORS, ROAD BUILDERS, PIT AND QUARRY

GRAVEL AND REJECTION CRUSHER
8 x 18 in., 8 x 24 in., 8 x 36 in.

Pit and Quarry operators and all others interested in crushed stone production, should know that they can eliminate complicated and expensive machinery, save time, labor, money, and secure a much finer and more uniform crushed product by the use of Universal Steel Crushers. For ordinary gravel and rejection crushing use our "800" line. Waste no more time returning your rejections again and again. Install one of these machines and do this work in one operation. An ideal crusher for sand and gravel pits.

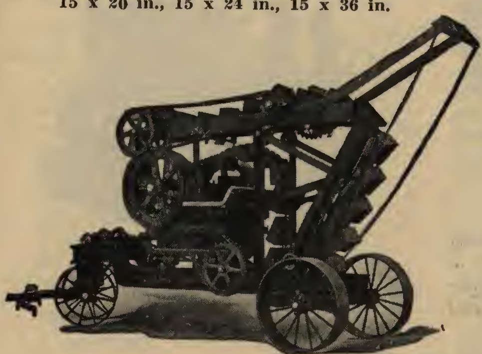
For coarse gravel, "niggerheads" and stone of the trap-rock variety too large for the 8-in. opening we recommend our "1200" line. These machines with all Steel frame have been so carefully designed that they are unbreakable and will last a lifetime. The "1500" line with still larger openings are recommended for granite, limestone and general quarry work.



HEAVY DUTY GENERAL CRUSHERS
12 x 20 in., 12 x 24 in., 12 x 36 in.
15 x 20 in., 15 x 24 in., 15 x 36 in.

Universal Crushers are noted for their simplicity of design and operation. Equipped with Manganese Jaws and Liners, Phosphor Bronze Bearings, extra heavy high carbon steel Eccentric Shafts, Steel Split Pitmans, Ring Oilers, and instant adjustment for fine or coarse material while the machine is in operation.

A full line of smaller sizes with feed openings 4x6 in., 5x6 in., 8x8 in., 8x12 in., 9x14 in., 9x16 in. and 10x16 in. Any crusher can be mounted on truck with or without elevators in style shown by illustration. A complete stock of repairs for Universal and Eureka crushers ready for prompt shipment.



Pulverizers, Elevators,
Screens, Conveyors.

Write for circular.

PENNSYLVANIA CRUSHER COMPANY

General Offices: STEPHEN GIRARD BLDG., PHILADELPHIA, PA.

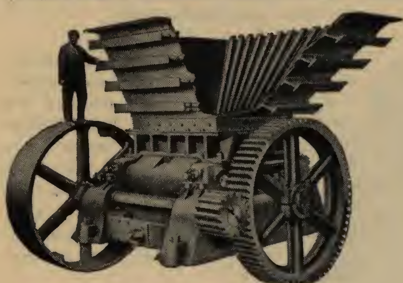
Branch Offices: Hudson Terminal, New York; Peoples Bank Bldg., Pittsburgh; Illinois Merchants Bank Bldg., Chicago.

PRODUCTS

"PENNSYLVANIA" GIANT Single Roll Primary Crushers for Limestone, Cement Rock, Lump Lime, Gypsum and Shale.

"PENNSYLVANIA" Hammer Crushers—SUPER, THOR, AJAX, SAMPSON and TROJAN Series for Secondary and Finer Reductions of These Materials, and KINGCOAL Series for R. O. M. Bituminous Coal.

"PENNSYLVANIA" ARMOR-FRAME Single Roll Coal Crushers for Preparing Producer and Stoker Coal.

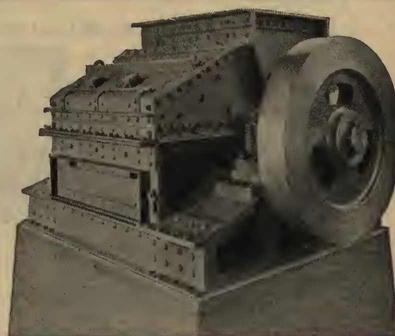


"PENNSYLVANIA" GIANT Single Roll Crushers are built in capacities ranging from 200 to 600 tons hourly for primary crushing, and smaller sizes for secondary reductions.

"PENNSYLVANIA Single Rolls are simple, powerful, self-feeding Crushers which make maximum reduction in one operation to relatively uniform product. The H. P., headroom, attendant labor, maintenance, and fines produced are minimum. The few parts are readily accessible. Crushers are adjustable and thoroughly protected against "Tramp Iron."

Bulletins, 1003 and 1005.

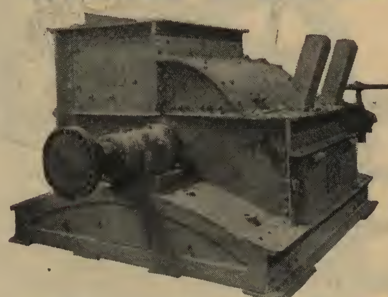
'PENNSYLVANIA" Steel-built Hammer Mills are furnished in 5 Series for secondary and finer reductions in heavy duty Cement and Lime Plant service, as follows:



"PENNSYLVANIA" SUPER Series.

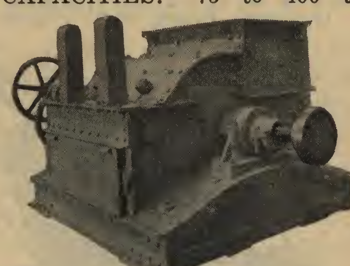
SERVICE: 12″ to 24″ feed, reducing as fine as ¾″ and under in one operation.

CAPACITIES: 100 to 500 tons.



SERVICE: 8″ to 15″ feed, reducing to ½″ and under product.

CAPACITIES: 75 to 400 tons.

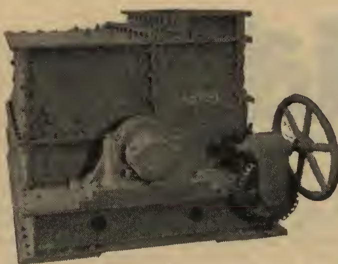


SERVICE: 4″ to 12″ feed, reducing down as fine as ¼″.

CAPACITIES: 45 to 300 tons.

PENNSYLVANIA CRUSHER COMPANY

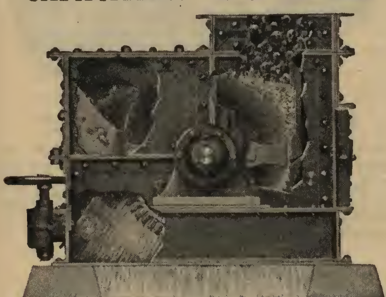
PENNSYLVANIA CRUSHER COMPANY



"PENNSYLVANIA" SAMPSON Series.

SERVICE: 2″ to 5″ feed, reducing to ⅛″, also 20 mesh.

CAPACITIES: 15 to 150 tons.



"PENNSYLVANIA" TROJAN Series.

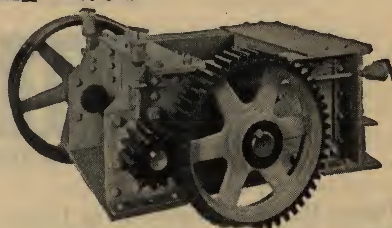
SERVICE: 2″ to 4″ feed, reducing to as fine as 30 mesh.

CAPACITIES: 2 to 70 tons hourly.

Distinctive "PENNSYLVANIA" Features: Heavy Fabricated Unbreakable Steel Frames, Adjustable (except Super) Steel Cages,
Patented Tramp Iron Separator,
Oversize Heavy Duty Bearings,
Adjustable Breaker Plates,
Powerful all-steel Rotors,
All Steel Internal Parts.

Capacities range from 2 to 500 tons hourly.

Bulletin 1005.

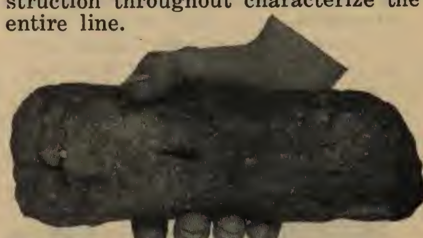


"PENNSYLVANIA" Single Roll Coal Crushers, built in capacities of 10 to 400 tons hourly, for reducing R. O. M. Bituminous coal to the sizes required by Gas Producers and Automatic Stokers, and preparatory to pulverizing.

The design provides slab steel frames in the smaller sizes and heavy box type, sectionalized frames for the larger sizes, re-enforced with heavy steel tie rods.

These "PENNSYLVANIA" Coal Crushers are self-feeders and insure uniform, uninterrupted production on account of the rugged construction, and triple "tramp iron" protection.

Patented Segmental Roll, Spring Suspended Breaker Plate, with special Manganese Renewable Tip, liberal Bearings, Steel Shear Pin Safety Device and powerful, substantial construction throughout characterize the entire line.



This Steel Wedge weighing 16 lbs. was automatically picked out from Primary Crusher feed without the knowledge of the operator or damage to the SUPER.

"PENNSYLVANIA" PATENTED STAMP IRON SEPARATOR is optional equipment in all "Pennsylvania" Steel-built Hammer Mills.

PUT YOUR REDUCTION PROBLEMS UP TO US.

WILLIAMS PATENT CRUSHER & PULVERIZER CO.

701 MONTGOMERY ST., ST. LOUIS, MO.

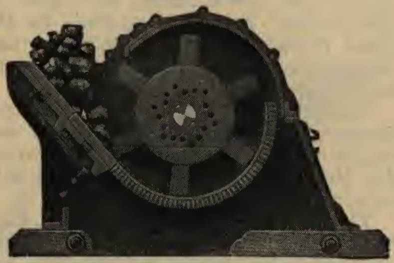
CHICAGO, 37 W. VAN BUREN ST. — SAN FRANCISCO, 67 SECOND ST.
NEW YORK — PHILADELPHIA — SCRANTON — SEATTLE — SALT LAKE CITY
RICHMOND — CHATTANOOGA — DENVER — ROCHESTER — DETROIT

Williams

PATENT CRUSHERS GRINDERS SHREDDERS

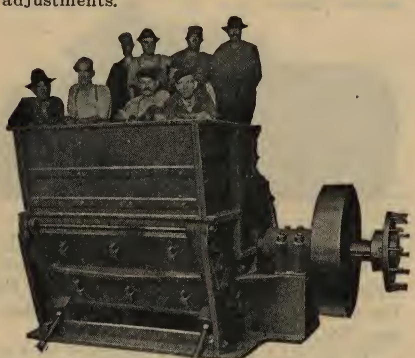
PRODUCTS

Hinged Hammer Crushers and Pulverizers. Also Roll Crushers, Screens, Automatic Feeders, Conveyors and Elevators.



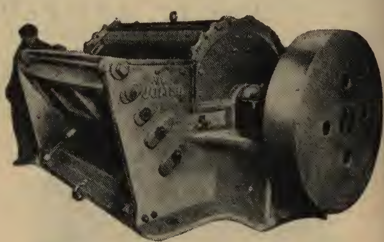
THE HINGED HAMMER PRINCIPLE

Invented by Williams. Consists of rows of heavy hammers loosely hung from bolts, running through discs, all mounted on substantial shaft. Fast revolving hammers crush material to proper size to pass through grates. Size of finished product regulated by openings in grates and other adjustments.



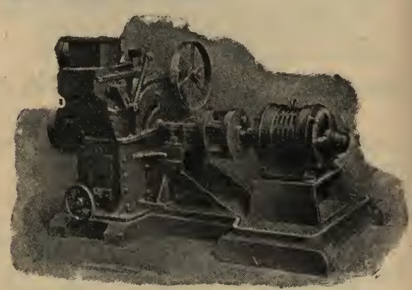
CRUSHES 48″ STONE TO 1½″

Williams Mammoth Crusher reduces 48″ cube stone to 1½″ in one operation. Takes the place of preliminary and 2 or 3 secondary crushers. Reduces initial investment 50%, also lowers rock crushing costs. Eliminates connecting elevators, conveyors and screens—reduces power consumption, building requirements and floor space. Crushes any size stone very uniformly. Write for service records in prominent plants.



CRUSHES 14″ STONE TO 1½″

Williams Jumbo Crushers are used by majority of American cement plants. Crushes product of largest Jaw or Roll Crushers, also 14″ stone to 1½″ and finer. Unequalled for asphalt rock, macadam or agricultural limestone.



PULVERIZERS

Thirty types and sizes of Williams Hinged Hammer Pulverizers. Universal type shown above grinds to 16 to 40 mesh and finer without aid of outside separation.

COMPLETE PLANTS

Complete plants designed, erected and equipped for the reduction of any material. Describe your work to our Engineering Department, full information gladly furnished.

AMERICAN MANGANESE STEEL COMPANY

GENERAL SALES OFFICES, 387 E. 14TH ST., CHICAGO HEIGHTS, ILL.

PLANTS: CHICAGO HEIGHTS, ILL. NEW CASTLE, DEL. OAKLAND, CAL.

AMSCO

PRODUCTS

AMSCO manganese steel dippers, and AMSCO manganese steel dipper fronts, teeth, bottoms and bails.

AMSCO manganese steel pumps and parts are catalogued on page 291

AMSCO manganese steel chain is catalogued on page 211

Ask for Our Catalogue.

MISSABE DIPPERS

Missabe dippers, of AMSCO manganese steel are noted for their wear resisting qualities and are especially suited to the handling of abrasive material.

The Missabe dipper with Vanderhoef front is built on correct principles—and is AMSCO manganese steel throughout. We consider its design the best ever developed. Its construction enables it to withstand extremely hard usage and to give maximum yardage at minimum maintenance cost.

DESCRIPTION

The body proper consists of a front and a back casting riveted together, affording a very rigid construction with fewest possible parts.

The bail brackets are located in the front casting, set at the proper angle to conform to the line of pull on the bail. The brackets abut against shoulders at the sides and top, relieving the bail bracket rivets of excessive shearing strains and eliminating tendency of bail brackets to work loose.

The usual form of the Vanderhoef front is with the lip and front cast intregral, while the ribs run down the outside instead of inside. These ribs add to the rigidity of the solid AMSCO manganese steel front and act as protecting guards, materially lengthening the life of the dipper.

All pin holes are fitted with renewable keyed type Manganese Steel Bushings.

We carry a complete line of dipper patterns for all capacities.

MANGANESE STEEL DIPPER TEETH

The Clark reversible tooth is a heavy duty type tooth designed to meet severe digging conditions. Its design is standard and has been recommended by many of the ablest and most experienced operators.

When the points, after long usage have worn to such an extent as to reduce efficiency, they are reversed, thereby providing a new cutting edge.

The Panama reversible tooth has the distinction of having given satisfactory service in all kinds of work throughout the country.

Vanderhoef teeth for Vanderhoef fronts are furnished in two patterns—pick or wedge type.

We also manufacture one piece teeth of AMSCO manganese steel in all types and sizes to suit any requirements.

The information required to fill orders is as follows: Make, model, yardage and type of dipper. If obtainable we should also be given the pattern number of teeth.

We also manufacture AMSCO manganese steel dipper lips, bottom bands, bails, etc., for all steam shovels and dipper dredges.

In ordering please state size and type of shovel as well as capacity of dipper.

GODFREY CONVEYOR COMPANY

ELKHART, INDIANA

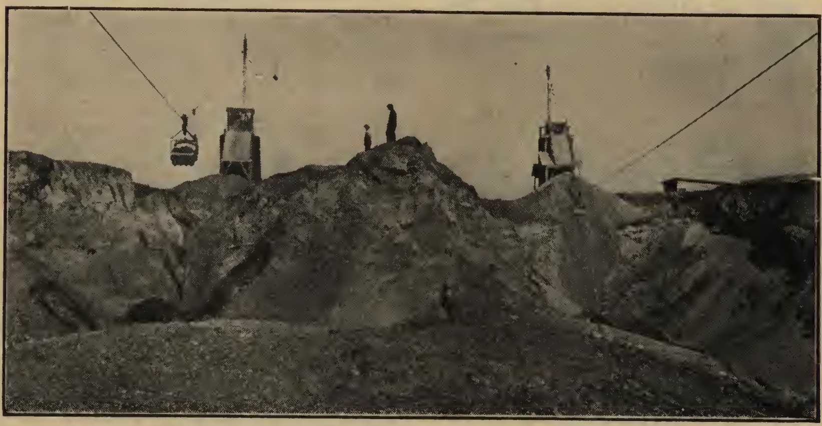
PRODUCTS

Dragline Excavators, Portable Belt Conveyors, Monorail and Cableway Installations, Self-dumping Buckets, Hoists, Trolleys, Pulleys, Sheaves and in fact almost everything in the conveyor field.

Ask for Catalog N.

SERVICE

All Godfrey products are manufactured by the Godfrey Conveyor Company. The factories and home offices are situated at Elkhart, Indiana, with branch offices in all principal cities. One of the big advantages in using Godfrey equipment is the quick service rendered at all times. A large and complete stock of spare parts for immediate shipment insures Godfrey users against costly delays and great inconvenience.



ADAPTATION

This company is devoted exclusively to the manufacture of high grade conveying machinery, being the originators and inventors of numerous types of equipment now on the market.

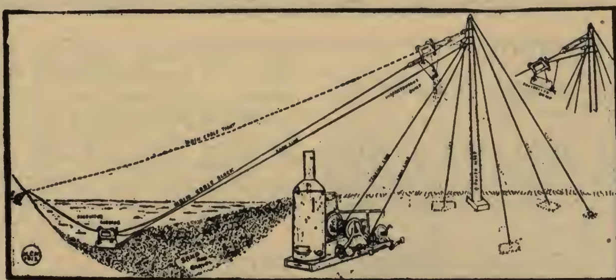
The Godfrey product most adaptable to the requirements of the readers of this book is the Dragline Excavator shown above. This outfit consists of the hoist, bucket, trolley, pulleys, sheaves, cable, etc., complete with all necessary fittings. It handles gravel, sand, marl, lime, cement and similar materials at the rate of from twenty to thirty yards per hour. Actual photographs of the various units, together with complete specifications and prices will be gladly mailed upon request.

INFORMATION

An engineering staff is maintained for the purpose of determining the adaptation of Godfrey equipment to the individual requirements of those contemplating the installation of conveying machinery. An inquiry addressed to the home office will receive immediate attention and a rough pencil sketch or brief description of your requirements will enable the engineering department to submit a careful analysis of your problem, without cost or obligation to you.

INDIANAPOLIS CABLE EXCAVATOR CO.

1019 PEOPLES BANK BLDG., INDIANAPOLIS, IND.



PRODUCTS

Negley slack cable way excavator

Write for our Catalogue

NEGLEY EXCAVATOR

Where it is possible to use the slack cable way system of excavation, the Negley excavator is constructed and operated so as to do the work at minimum cost. These excavators are now in use in many plants in both the United States and Canada, and working successfully under varied conditions.

CONSTRUCTION

The excavator proper consists of Carriage, Latch and Bucket. The Latch consists of two heavy arms, which describe a radius above the pivot, between the lower ends of which is riveted a heavy iron hook which serves to engage the cross bar on the top of the bucket and carries the load in transmission. This Latch is pivoted in the Carriage, so that nearly all of the weight of the entire Latch is in front of the pivot center, assuring the rapid engagement and retention of the hook.

The Bucket is of one piece construction, except that the back is riveted in. For hard digging the bucket is equipped with Manganese Steel Teeth.

The attachment used for discharging the load at the lower end of the track cable consists of extended reinforcement plates at the rear track sheave, a U shaped iron, and a bar connecting this with the top of the latch arms. This attachment can be put in place or removed quickly.

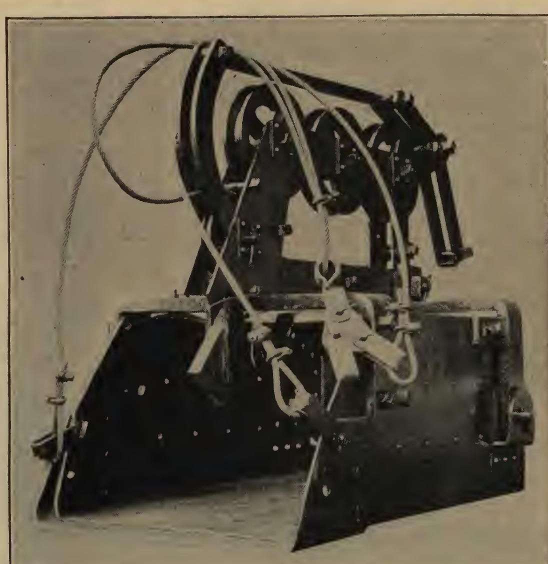
INSTALLATION

The Negley excavator can be installed economically. The kind and quantity of equipment depends upon the size of the Excavator, the nature of the material, the distance of the haul and depth of the material.

The mast or tower should be tall enough to give the track cable a fall of from 10 to 15 feet in each 100 feet, depending upon the distance of the haul. The track cable should be long enough to reach from the farthest point of the excavation to the mast.

Any two drum friction hoisting engine is adaptable to the operation of this Excavator. The front drum operates the load line and the rear drum operates the tension line.

The Negley Excavator is shipped ready to be mounted on the track cable.



MONIGHAN MACHINE CO.

2036 CARROLL AVE., CHICAGO, ILL.

PRODUCTS

Monighan Walking Dragline Excavators

THE MONIGHAN

The Monighan Walking Dragline Excavator has embodied in its design the experience gained from many years of specializing in dragline excavator machinery construction The increased portability, the large capacity, and remarkable economy of the Monighan, equipped with walking device makes it the highest achievement in dragline excavator construction.

DATA, DRAGLINE EXCAVATORS

Dragline Excavators Equipped with Walking Devices

Type number of excavator	No. 1½-T Fuel Oil Power	No. 2-T Steam Power	No. 2-T Fuel Oil Power	No. 3-T Steam Power	No. 3-T Fuel Oil Power
Length of boom	50 ft.	60 ft.	60 ft.	70 ft.	70 ft.
Capacity of bucket	1½ cu. yds.	2 cu. yds.	2 cu. yds.	3 cu. yds.	3 cu. yds.
Size of main engine		9″x10″		10″x10″	
Size of swinging engine (rack & pinion type)		6¼″x8″		6¼″x8″	
Size of locomotive boiler		54″x12′-3″		54″x13′-7″	
H. P. of oil engine	75		75		100
Shipping weight (without counterweight)	54 tons	75 tons	80 tons	95 tons	102 tons

Dragline Excavators Mounted on Skids and Rollers

Type number of excavator	No. 2-S Steam Power	No. 2-S Fuel Oil Power	No. 3-S Steam Power	No. 3-S Fuel Oil Power
Length of boom	60 ft.	60 ft.	70 ft.	70 ft.
Capacity of bucket	2 cu. yds.	2 cu. yds.	3 cu. yds.	3 cu. yds.
Size of main engine	9″x10″		10″x10″	
Size of swinging engine (rack & pinion type)	6¼″x8″		6¼″x8″	
Size of locomotive boiler	54″x12′-3″		54″x13′-7″	
H. P. of oil engine		75		100
Shipping weight (without counterweight)	60 tons	65 tons	75 tons	82 tons

SAUERMAN BROS.

426 S. Clinton St., CHICAGO, ILL.

Agents in 25 principal cities

PRODUCTS

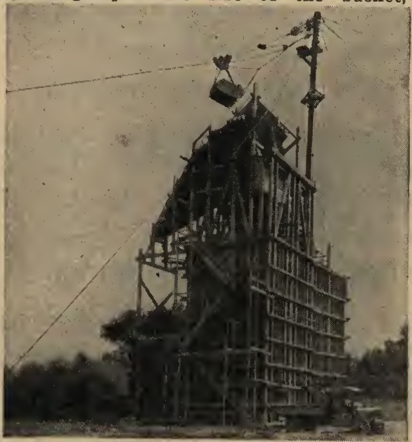
Sauerman Cableway Excavators
(Write for Pamphlet No. 17)
Power Drag Scrapers and Portable Scraper Outfits (See Page 300)
Cableway and Scraper Hoists, Wire Rope, Sheaves and all Cableway and Scraper Fittings

CABLEWAY EXCAVATORS

Advantages. In digging sand and gravel from a river or pit, a Sauerman Cableway Excavator digs, conveys and elevates in one continuous movement and one man controls the entire operation. Without the help of auxiliary equipment or labor it handles the material from the place of excavation direct to the screens or hopper on top of the plant at a minimum cost per yard. It digs as well under water as in the dry and to the full depth of the deposit.

Sizes. Buckets for standard Sauerman Cableways are built in 6 sizes, in capacities of 1/3, ½, ¾, 1, 1½ and 2 cu. yd. and any length of span up to 1,000 ft. or more can be furnished, although operating spans longer than 700 ft. are not often required. Sauerman "Junior" Cableways, intended for small propositions, are equipped with buckets of lighter construction in 6, 9 and 13 cu. ft. sizes and have operating spans of 300 ft.

Capacities. The amount of material handled per hour ranges from 10 to 100 cu. yds. depending upon the size of the bucket,



Dumping Into Hopper 80 Ft. High

400-ft. Span Sauerman Cableway

Bucket Digging in Dry Pit

length of span, condition of material and industry of operator. A 600 ft. span machine working a deposit 90 ft. deep dug over 500,000 cu. yd. at one set-up.

Power. Sauerman cableways and power scrapers are operated by double-drum hoists, either steam, electric, gasoline or belt-driven. Maximum capacity is obtained with Sauerman power units, especially designed for this purpose.

The portable scraper outfits and "Junior" Cableways are equipped with gasoline or belt-driven power units mounted on trucks.

Maintenance. All Sauerman machines are manufactured on the interchangeable duplicate part system and repair parts are easily installed in the field. A complete stock of parts is always on hand at Chicago, and at several branch warehouses, insuring immediate shipment.

Maintenance costs on Sauerman machines are relatively low as all wearing parts are specially bushed, adequate lubrication is provided, and operating cables are of selected steel for dragline duty.

BAY CITY DREDGE WORKS

BAY CITY, MICH.

PRODUCTS

Bay City One Man Excavator, Bay City Excavator Model-15, Excavator-Crane Mod. 16, Bay City Dredge.

Write for our catalogues.

THE ONE MAN EXCAVATOR

The Bay City One Man Excavator has been developed to meet the need for a light economical excavator and loader to fill the gap which has always existed between heavy and expensive shovel equipment and hand labor. Used for digging, loading and stripping.

The endurance and digging powers of this little machine is surprising as well as its low operating cost. You are offered your choice of gasoline, kerosene or electricity for power. Operates shovel or clamshell.

DESCRIPTION

There are two models of one Man Excavators—either track or crawler type. The frame work is of structural steel thoroughly braced. The standard length of boom is 24 feet but can be furnished in any length up to 30 feet.

Power is furnished by either 12 H. P. Hercules single cylinder gasoline or natural gas engine; or 20 H. P. Reliable 2-cylinder opposed type Gasoline or Kerosene Engine; or 15 H. P., Electric Motor. Clutch pulleys furnished with engine.

The mounting consists of flanged wheels and short sections of portable track, or all steel caterpillar type treads under front axle, with differential and heavy double chain drive. Broad road wheels and steering device for rear axle. (Caterpillar machine propelled forward or backward with equal ease.)

TERMS

Monthly payments or discount for cash.

MODEL 15-EXCAVATOR

Bay City Excavator (model 15) is a larger, more powerful machine, built along the same lines and having the same ease and economy of operation. Capacity ⅝ or ¾ yd. Operates dipper or clamshell.

BAY CITY LAND DREDGES

Are well known in the drainage and irrigation fields. They are furnished in different sizes with capacities of ½ to 1½ cubic yards.

CRANE-EXCAVATOR MODEL 16

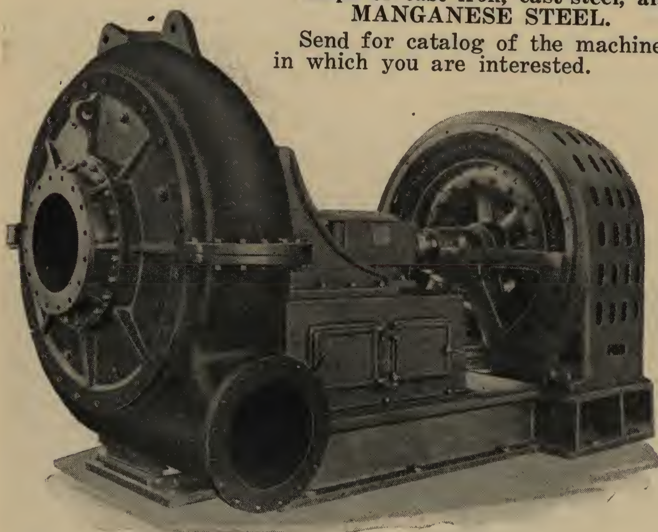
A convertible machine operating shovel, dragline, clamshell, skimmer, ditcher or magnet. One man operation, caterpillar mounting, gasoline or electric power.

ELLICOTT MACHINE CORPORATION

1120 Bush Street, BALTIMORE, MARYLAND, U. S. A.

Pumps of cast iron, cast-steel, and MANGANESE STEEL.

Send for catalog of the machinery in which you are interested.



Motor Driven Gravel Pump

For over 35 years we have specialized in the manufacture of Hydraulic Dredges for sand and gravel, bucket and elevator type dredges, sand and gravel pumps, and dredging machinery.

Elevator Dredge—Capacity 250 Cubic Yards of Washed Sand and Gravel Per Hour.

CHICAGO PNEUMATIC TOOL CO.

CHICAGO PNEUMATIC BLDG.

6 EAST FORTY-FOURTH ST., NEW YORK, N. Y.

PRODUCTS

Compressors, Air
Drills, Rock
Engines, Oil
Hoists, Air

SERVICE

Complete stocks of Chicago Pneumatic products are usually available at the Branches listed on page 193.

CP HAND HAMMER ROCK DRILLS

CP HAND HAMMER ROCK DRILLS are rapid, powerful, symmetrical, economical and easy to handle. They are made in wet and dry types. They drill holes to an economical depth of from 6 to 16 feet and weigh 40 to 60 pounds, depending upon the type of drill used. Their principal features are: Practically all-steel, bolted construction. No screwed joints. Reversible ratchet pawls and ratchet ring which double service. Cylinder-housed valve, which obviates leakage. Fully balanced, rapid, positive-acting spool valve that insures high-cutting speed. Swiveled air connection which permits hose to hang parallel with the drill. Throttle valve which turns freely at all pressures. Effective blowing device which clears cuttings to a 25-foot depth. Request Special Publication 697, which illustrates and describes CP Rock Drills in mounted, unmounted, wet and dry types.

Specifications—Hand Hammer Drills

Type	CP-8	CP-8W	CP-8A	CP-10	CP-10W
Diameter of cylinder, inches	2½	2½	2½	2½	2½
Length of stroke, inches	2⅛	2⅛	2⅛	2⅝	2⅝
Net weight, pounds	40	41	40	56	60
Length overall (without steel retainer), inches	19	19	19	21¼	21¼
Air Hose, inches	¾	¾	¾	¾	¾
Water Hose, inches	....	½	....	....	½
Hollow hexagon drill steel, inches	⅞	⅞	*⅞	**1	**1
Steel shank, inches	⅞x3¼	⅞x3¼	⅞x3¼	1x4¼	1x4¼
Economical drilling, depth, feet	10-12	10-12	6-8	14-16	14-16
Weight with regular equipment, boxed, lb	59	63	59	76	84

* For auger work, as in iron ore, 1½ in. solid, twisted auger steel, diamond section, is used. Shank is standard, ⅞x3¼ in.

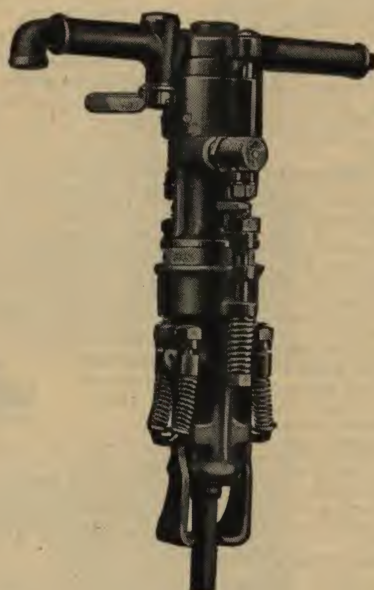
** ⅞ in. hexagon, hollow steel also quite generally on this drill.

THE CLEVELAND ROCK DRILL COMPANY

3734 East 78th Street, CLEVELAND, OHIO

PRODUCTS

No. "Forty-Four" Cleveland Rotators for air only. No. A-1 Cleveland Rotators for air or steam. Cleco Valves, "Neverleak" Couplings, "Veribest" Hose



No. 44 Rotator

ARE YOU INTERESTED IN

Speeding up your work?

Decreasing your drilling costs?

Giving your men machinery which is easier to handle and less tiring?

IF YOU ARE

Investigate Cleveland Rotators. The No. "Forty-Four" Cleveland is guaranteed to be the fastest cutting Rotating Drill on the market and at the same time it is the most economical from point of maintenance.

THE SANDERSON-CYCLONE DRILL CO.

ORRVILLE, OHIO

EASTERN AND EXPORT OFFICE: 30 CHURCH ST., NEW YORK

PRODUCTS

Big Blast Hole Drills of the Well Driller or Cable Tool Type, built in Traction or Non-Traction Styles, equipped with Gasoline, Electric, Steam or Compressed Air Power. Drilling and Fishing Tools and Drilling Supplies.

CYCLONE NO. 14 BIG BLAST HOLE DRILLS

Cyclone No. 14 Big Blast Hole Drills are especially built for quarry work, differing from the ordinary well drill both in design and construction. They will operate heavy tools at a speed of 60 to 63 strokes per minute, essential for efficient results. The metal operating parts are CAST STEEL; the wood parts are best grade straight grained Oregon fir; all shafting is cold rolled steel. There are two sizes—No. 14 Standard and No. 14 Junior.

THE NO. 14 STANDARD DRILL

The No. 14 Standard drill, the largest size, is recommended where maximum results in footage are desired. It will carry drill stems 4, 4¼ or 4½ inches in diameter by 20 feet long with drill bits for 5, 5⅝, 6-inch or even larger holes. For limestone quarries of daily tonnage capacity of 600 tons or over and on extremely hard rocks such as granite, trap rock or quartzite, the No. 14 Standard should be employed.

THE NO. 14 JUNIOR DRILL

The No. 14 Junior drill will handle 3, 3¼ and 3½-inch drill stems, 20 feet long with bits for 4, 4¼, 4½ or 5-inch holes. It is suitable for quarries producing limestone, sandstone, shale, cement rock where the tonnage requirements range from 100 to 500 tons of raw material or in plants of large capacity where the rock moving conditions necessitate smaller blast holes and closer spacing.

CYCLONE DRILLING TOOLS

All drilling and fishing tools furnished with Cyclone Blast Hole Drills are made in our own factory, where we can control the material and workmanship that go into them and are thus in a position to cover them with a rigid guarantee.

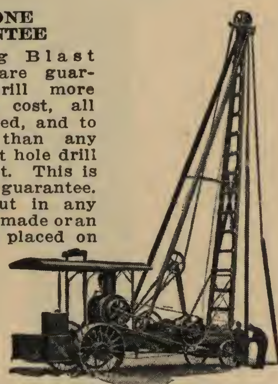
TRADE MARK CYCLONE DRILLS A PLEDGE OF SERVICE

CYCLONE SERVICE

One phase of Cyclone service is the sending of a practical sales engineer—one who has had years of experience in quarry drilling and blasting—to look over the quarry layout for the purpose of recommending the system of operation and drilling equipment, and estimating drilling and blasting costs. No obligation is thus incurred by the prospective buyer. Experienced drill operators are supplied when desired, at current wage rates. Drilling tools and spares are shipped immediately from stock. Assistance in solving any drilling and blasting problems arising after the installation of the drill will be furnished.

CYCLONE GUARANTEE

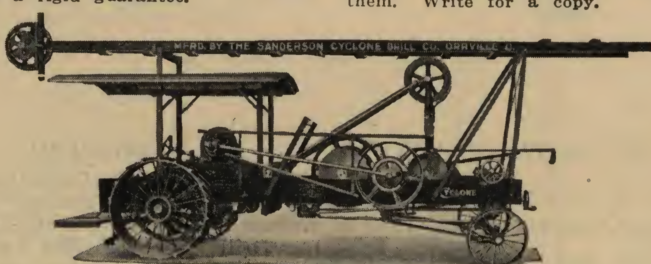
Cyclone Big Blast Hole Drills are guaranteed to drill more hole at less cost, all costs considered, and to live longer than any other big blast hole drill on the market. This is not a paper guarantee. It will be put in any sales contract made or an outfit will be placed on your work in competition with any or all other makes of drills. If the Cyclone does not outdrill and outwear the other makes of drills, we will remove it from your job without cost or risk to you.



No. 14 Gasoline Traction Drill

CATALOG B-45—BIG BLAST HOLE DRILLS

This is a 100-page book, the first 40 pages of which deal with semi-technical information pertaining to big blast hole drilling, including cost data. The balance of the book describes in detail Cyclone No. 14 Drills and the drilling tools used with them. Write for a copy.



No. 14 Electric Traction Drill

THE C. O. BARTLETT & SNOW CO.

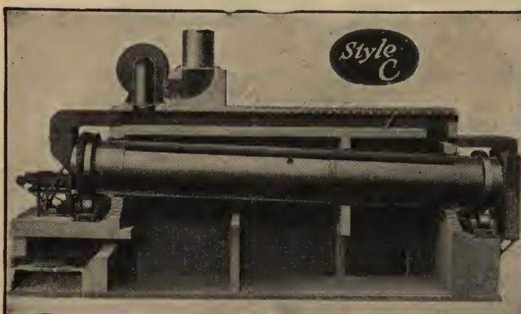
1100 French St., CLEVELAND, O.

PRODUCTS

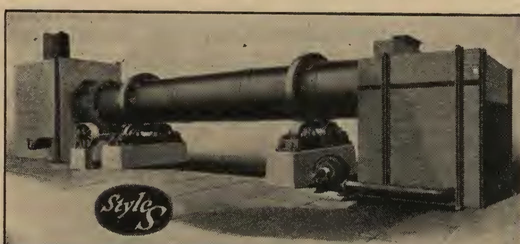
Dryers for all materials; Elevating and Conveying Machinery; Skip Hoists; Crushers; Pulverizers; Screens; Feeders; Complete Plants for Drying, Crushing, Screening, Washing. **See also, page 249.**

Bartlett and Snow Dryers comprise thirteen different types, each one of which has been developed for drying a certain class of materials. More than a thousand are now in operation drying sand, stone, coal, ore and various other materials.

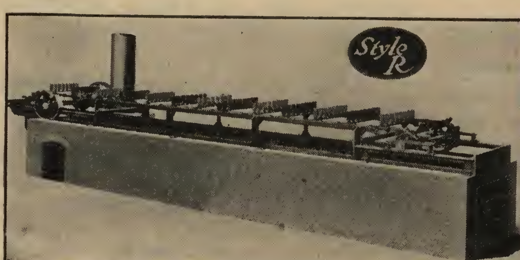
We'll be glad to tell you which dryer will do your work properly. Just tell us the hourly tonnage, the amount of moisture in the wet material, and the desired dryness of the product.



This machine drys with less fuel than any other machine and takes less power. The heat goes first around the outside of the cylinder and then through the inside. The shell is split up into four compartments with spaces between which increase the heating surface about 70%. Used for sand, stone, coal, and ores.



Though not as efficient as the Style C dryer, this machine is well fitted for drying sand, stone, and ore. Here the heat comes into direct contact with the material, resulting in quick drying and large capacity. This makes a good simple machine for those conditions which demand moderate first cost.



This is the proper dryer for materials which are so fine that drying in a rotary dryer causes excessive dust loss. The material is dried on a cast iron hearth, heated from below. A series of moving rabbles keeps the material in constant, gentle motion and slowly moves the material the full length of the hearth.

RUGGLES-COLES ENGINEERING COMPANY

Established 1897

120 Broadway, NEW YORK, N. Y.

BRANCH OFFICE—Newhouse Bldg., SALT LAKE CITY, UTAH

WORKS—YORK, PENNA.

Class "A" Dryer Showing Flow of Gases

PRODUCTS

Ruggles-Coles Dryers for drying by means of Direct Heat, Indirect Heat, or Steam

Special Dryers constructed for materials having unusual characteristics.

Designers and Builders of Dryers for All Materials

Class "A" Dryer—Double Shell Direct Heat.

The temperature for drying in this dryer ranges between 200° and 400° Fahr., depending upon the material to be dried. This dryer is built in 7 standard sizes.

Operation—This dryer is especially adapted for drying coal, coke, ores, rock, stone, sand, concentrates and similar materials.

Class "B" Dryer—Double Shell Indirect Heat

This type of dryer is especially adapted for drying those materials which can be dried at fairly high temperature but which must not come into contact with the products of combustion, due to possible injury or contamination.

Operation—This dryer is especially adapted for drying china clays, talc rock, whiting and kaolin.

Class "C" Dryer—Rotary Steam

There are many materials which cannot be dried by direct heat or even indirect heat due to high temperatures causing injury to the material, hence a Ruggles-Coles steam dryer has been developed to handle such materials.

Operation—This dryer is especially adapted for drying brewers' grains, cotton seed, starch feed, tobacco stems, and corn germs.

Class "D" and Class "E" Dryers—Paddle Type

These are distinct paddle dryers built in special sizes for direct heat, indirect heat, or steam, depending upon the material to be dried.

Class "F" Dryer—Single Shell Direct Heat

This is a simple dryer especially adapted for drying those materials which are not affected by furnace gases.

Write for Catalog No. 16

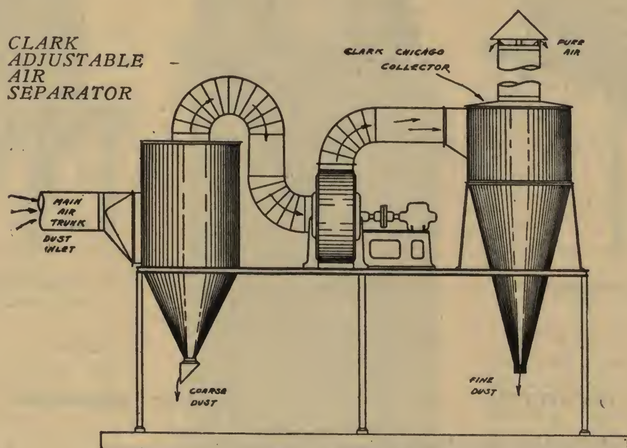
CLARK DUST COLLECTING CO.

FISHER BUILDING, CHICAGO

PRODUCTS

Clark Dust Collecting Systems. Write for Bulletin 100 & 200

OUR ALL-METAL SYSTEM



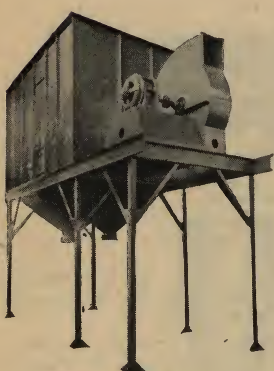
CLARK DUST SYSTEMS

The Clark All Metal System consists of Clark Chicago Collector, Fan and Adustable Air Separator. This system can be used for the collection of dust of any kind. Occupies minimum space. Durable and efficient. The Clark Adjustable Air Separator insures longer life to the fan by trapping out the abrasive dust ahead of the fan, making two or more classifications of dust collected.

Can be applied in stone crushing and pulverizing plants and for producing the following products—Commercial Fertilizer, Asphalt Filler, Chick Food Products, Paint Filler, etc. We can deliver any fineness or mesh product required. Highest collecting efficiency guaranteed.

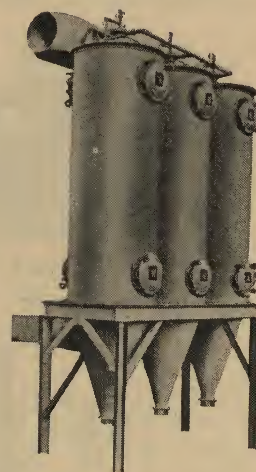
THE NORTHERN BLOWER CO.

CLEVELAND, OHIO



Dust Arrester

Cyclone Arrester



Dust Filter

PRODUCTS

Dust Collecting Systems
Engineering Service
Blow Piping
Ventilators
Fans
Pneumatic Conveying
Sand Blast
Sheet Plate Work
Structural Steel Work

PROFIT FROM DUST

Dust, in many cases, is a destructive evil which can be turned from a loss to a profit in the manufacture of many products, such as glass, cement, lime grinding, phosphate, graphite, chemicals, etc.

The collection of air flotation dust proves valuable and, in many instances, the cost of a complete modern dust collection system is soon saved.

Norblo Dust collecting systems are adequate in every way to handle your dust collecting problems. There are air separating and screening systems, special dust collectors for waste heat boilers, cloth filteration processes, special cooling systems for bagging, etc.

Consult our engineering department for the system best suited to your needs. Write for Bulletins

KUHLMAN ELECTRIC CO.

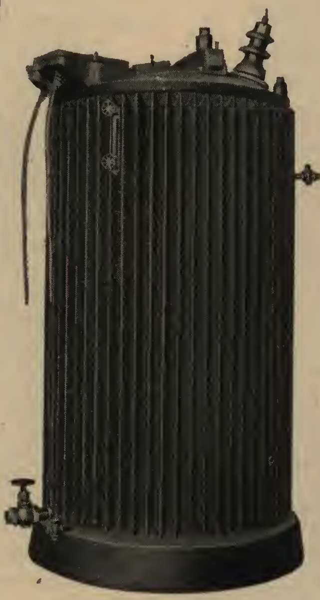
BAY CITY, MICHIGAN

PRODUCTS

KUHLMAN TRANSFORMERS

Kuhlman transformers are furnished for all classes of service. Standard types in 200 KVA capacities and less, special types for any requirements, Single Phase, Two Phase and Three Phase.

Cores are built up of thin laminations of non-aging steel so cut and stacked as to give a continuous magnetic circuit of low reluctance. Secured in rigid structural steel clamps which eliminate vibration of laminations and excessive humming.



Except on smaller sizes the round type of coil construction is employed. This results in increased oil space and circulation and removes danger of mechanical strains. After coils are wound they are treated by a vacuum drying and impregnation process. Insulating shield between primary and secondary windings is of mica and varnished cambric reinforced with rope paper which adds mechanical strength. Low voltage terminal wires paper insulated.

Terminals brought straight up from coils and out through outlet bushings that are 25 per cent. oversize.

Oil ducts, placed between high and low voltage windings and distributed through the windings themselves, maintain a low coil gradient. All transformers of 200 KVA 60 cycle or 150 KVA 25 cycle and larger have a mercury thermometer and glass oil gauge attached to the case, together with filter press connections.

Containers are of welded steel. A gasket provided under the cover renders the case air and moisture proof.

GUARANTEE

We guarantee transformers against lightning for first year, assuming installation of usual protective equipment. During first year will make free all repairs except those caused by excessive overloads or lack of arrester equipment.

SERVICE

Shipment of orders from stock same day is received.

A flexible organization ready to give emergency service at times.

Transformer Specialists for Thirty Years.

WESTINGHOUSE ELECTRIC & MFG. CO.

EAST PITTSBURGH, PENNA.

Offices in all Principal Cities

PRODUCTS

Steam Turbines, Electric Generators, Condensers, Stokers, Transformers, Switchboards, Circuit Breakers, Instruments, Electric Heating Apparatus, Electric Locomotives, Motors, Starters and Controllers.

Geared Turbine Generator

Westinghouse Electric can furnish all the apparatus necessary for the economical generation, transmission and utilization of electric power.

Distributing Transformer

Many years of development and steadily effected improvements have brought Westinghouse transformers to a high degree of perfection. Improvements have been made in the materials used, in their design and construction, and incorporated with all modern developments of good electrical engineering application.

Westinghouse offers many types of circuit breakers which give satisfaction in all kinds of industrial service. They successfully meet such conditions as overload or short circuit, underload, undervoltage, overvoltage and reverse current.

Circuit Breaker

Westinghouse motors are particularly adapted to the severe conditions met in the rock products industries. Their design is the result of many years of experience in the manufacture of motors for all industrial applications. They are rugged in construction and will give successful, uninterrupted service with a minimum of care and attention.

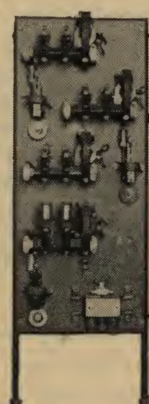
Induction Motor

Automatic Auto-Starter

Type CS motors are for constant speed service and are used for driving crushers, ball mills, conveyors, etc.

Loads that require extra heavy starting effort such as gyratory crushers, air compressors, conveyors, hoists, etc., can use the Westinghouse Type CW wound rotor induction motor.

Westinghouse can furnish manual and automatic control for every type of motor. Automatic control offers particular advantages in that no skill or experience is necessary to operate. The operation of a push button causes the motor to automatically accelerate to normal speed without danger to the operator or undue strain on the machine.



Automatic Starter

THE C. O. BARTLETT & SNOW CO.

1100 French St., CLEVELAND, OHIO

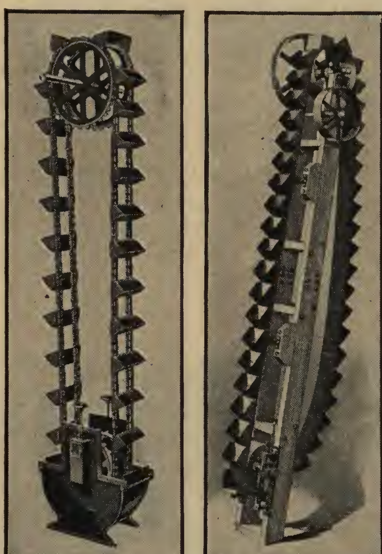
PRODUCTS

Conveying and Elevating Machinery; Skip Hoists; Dryers; Screens; Crushers; Pulverizers; Feeders; Complete Plants for handling Washing Drying and Crushing. See also, page 243.

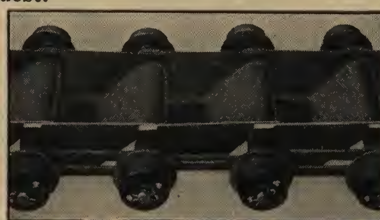
Organized in 1885, Bartlett and Snow have been building conveying and elevating equipment and skip hoists for thirty-seven years.

Cooperation is the essential work of the men in this organization. They will be glad to have your requirements put up to them, and will take pleasure in investigating your conditions thoroughly and offering specific suggestions backed up by many years of experience.

Complete 400 page catalog upon request.



Two of the 12 Types of Bartlett & Snow Elevators



Bartlett & Snow Common Sense Conveyor for Hot, Corrosive, and Abrasive Material

Typical Installation of Belt Conveyor

Typical Skip Hoist Installation

LINK-BELT COMPANY

PHILADELPHIA CHICAGO INDIANAPOLIS

New York	Woolworth Bldg.	Wilkes-Barre	2d Nat'l Bank Bldg.	Seattle	820 First Ave., S.
Boston 9	49 Federal St.	Huntington, W. Va.	Robson-Prichard Bldg.	Portland, Ore.	101 First St.
Pittsburgh	1501 Park Bldg.	Cleveland	429 Kirby Bldg.	San Francisco	168 Second St.
St. Louis	Central Nat'l Bank Bldg.	Detroit	4210 Woodward Ave.	Los Angeles	163 No. Los Angeles St.
Buffalo	547 Ellicott Square	Kansas City, Mo.	306 Elmhurst Bldg.	Atlanta	610-611 Citizens and S'thrn. Bk. Bldg.

Denver, Lindrooth, Shubart & Co., Boston Bldg.
Louisville, Ky., Frederick Wehle, Starks Bldg.
New Orleans, C. O. Hins, 504 Carondelet Bldg.
Birmingham, Ala., S. L. Morrow, 720 Brown-Marx Bldg.

Canadian Link-Belt Co., Ltd., Toronto and Montreal H. W. CALDWELL & SON CO. CHICAGO NEW YORK, Woolworth Bldg. [illegible] TEXAS, 709 Main St

PRODUCTS

Complete Sand and Gravel Washing and Preparing Plants, Stone and Lime Handling Machinery, Elevating, Conveying and Power Transmission Machinery, Locomotive Cranes, Crawler Cranes, Portable Loaders and Conveyers; Box Car Loaders, Dragline Excavators, Sand Separators, Bucket Elevators, Belt Conveyors, Screens, Chains, Wheels, Buckets, Gears, Pulleys, Clutches, Bearings, Hangers, Etc. Send for Catalogs.

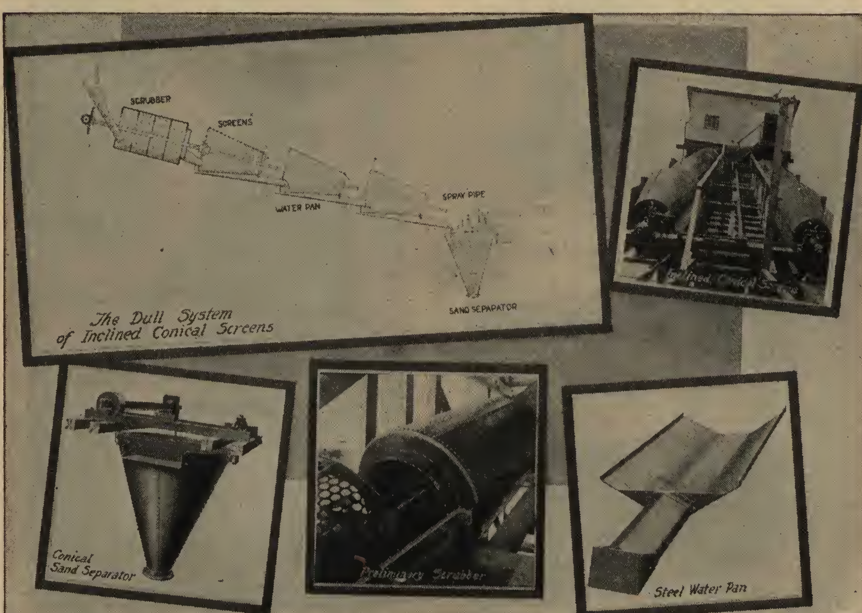
SAND AND GRAVEL PLANTS

Link-Belt engineers have spent years in the study and development of methods for the efficient production of sand and gravel. They are specialists in this work.

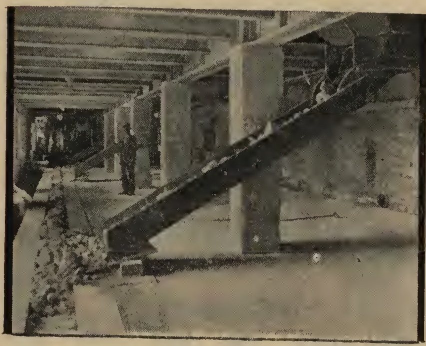
Each Link-Belt plant is built to secure the greatest commercial advantages for its owners—whether the desired output be 10 or 300 carloads a day.

Each plant has its individuality, and the details of design make it the most efficient for its work, from every standpoint of economy of operation—high quality of material—simplicity—durability—reliability, etc.

If you contemplate additions to, or changes in your present equipment, or a new plant, why not put your problem up to our engineers? Send for catalog.



LINK-BELT COMPANY



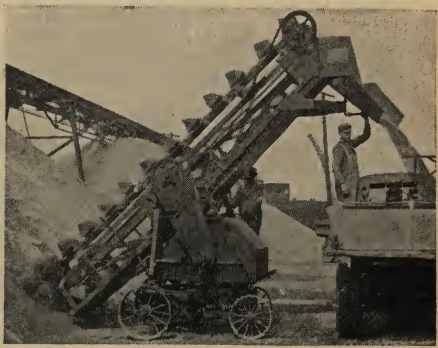
STONE AND LIME HANDLING MACHINERY

The use of Link-Belt lime handling equipment offers great possibilities for savings, longer output and greater efficiency in the handling of lime.

Lime is not difficult to handle by machinery. The intermittent service of the conveyors and the slow speed at which they run make for long life and low maintenance cost.

We have brought many old-fashioned plants up to date at a minimum of cost, and welcome the opportunity of talking this matter over with you.

Send for our new 80-page book No. 416. It contains facts and figures on the mechanical handling of stone and lime.



THE ONE-MAN POWER SWIVELING LOADER

The Link-Belt Power Swiveling Loader is the superior of any machine we have ever built for the loading of materials from ground storage—and we believe it is the superior of any similar machine on the market today.

It is really a one-man machine, no other helper is required when loading any material that will flow. The Link-Belt Power Swiveling Loader feeds from the piles, swivels and elevates all at one time, or it can accomplish any of these operations independent of the others—and all at the will of the operator, conveniently located on the platform.

THE LINK-BELT CRAWLER CRANE

Rugged, responsive; strong, yet light; the Link-Belt Crawler Crane is an ideal machine for road building, contract work, or excavating work. It is a one-man machine, because steering of the caterpillar truck is controlled in any position of the upper rotating base by a lever at the operator's stand in the cab. Complete specifications, price, and delivery upon request. Send for Booklet No. 595.

THE WEBSTER MFG. COMPANY

4500-4560 CORTLAND ST., CHICAGO

FACTORIES: Tiffin, O. Chicago, Ill. Michigan City, Ind.

SALES OFFICES: New York, Boston, Buffalo, Cincinnati, Cleveland, Philadelphia, Atlanta, Baltimore, Birmingham, Chattanooga, Columbus, Denver, Detroit, Knoxville, Louisville, Milwaukee, New Orleans, Pittsburgh, St. Louis, Salt Lake City, Seattle.

PRODUCTS

We Design and Build Complete Equipment for Handling Sand, Gravel, Cement, Gypsum, Lime, Etc.—Apron Conveyors; Belt Conveyors; Trippers, Bucket Elevators; Pivoted Bucket Carriers, Screens, Clutches; Steel and Malleable Chains; Sprockets; Gears; Buckets; Pulleys, Etc.

SERVICE:

Our engineering department is at your service to make recommendations for equipment to suit your requirements. Our factories are well equipped to give you the best of service in filling your orders.

Sand and Gravel Plants

APRON CONVEYORS

We design and build apron conveyors in widths ranging from 12 in. to 60 in. with steel car or malleable type of roller chain of 4 in., 6 in., 9 in. or 12 in. pitch. These will successfully handle a great variety of materials. They are used as feeders for conveying and elevating systems, as well as feeding crushers; they handle heavy and lumpy material over comparatively short distances, horizontally or on an incline.

Steel Apron Conveyors

BELT CONVEYORS

Our belt conveyor equipment is most complete, including various types of troughing carriers, trippers, etc., to suit requirements of individual installations.

Belt Conveyor—Carrier and Return

BUCKET ELEVATORS

Continuous bucket elevators are exclusively used for handling heavy material on either vertical or inclined lifts. This type of elevator is almost exclusively used in stone quarries, sand, gravel and lime plants. They are designed in many different lengths and capacities, mounted on steel or timber frames, can be furnished with malleable or steel buckets on chain or elevator belts.

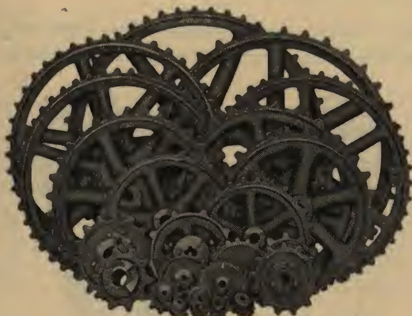
Continuous Bucket Elevator

SPROCKET WHEELS

Our pattern equipment for sprocket wheels is very complete and wheels for any size of chain can be supplied in either gray iron or chilled rim pattern.

Chilled rim sprockets have smooth, hard rim surfaces with deep chills which make them especially well adapted for severe service, such as handling sand, grit, ashes, cement or other abrasive material.

THE WEBSTER MFG. COMPANY



Sprocket Wheels

SCREENS

Webster screens are built in hexagonal or cylindrical types, single, double or multiple jacketed, of perforated plate or woven wire cloth. They can be furnished shaft or trunnion driven. Recommendations as to the type, and sizes to be made and prices quoted on receipt of data, stating fully the requirements as to capacity, nature of material, space limitations, etc.

Revolving Screens

CHAIN

We manufacture a large variety of steel and malleable chain from the smallest size detachable chain to the heavier steel bar roller chain. We carry a large and full stock of chain at our Chicago and Tiffin factories.

Malleable Roller Chain

Steel Bar Roller Chain

PERKINS PIVOTED BUCKET CARRIERS

Perkins Pivoted Bucket Carrier Handling Stone and Shale

The Perkins pivoted bucket carrier is used to a great extent in the cement mill for conveying hot clinkers from the kiln to coolers or to storage and conveying cooled clinkers from coolers to storage or direct to mill. The construction of the carrier makes it especially well adapted for enduring high temperatures of hot clinkers fresh from the kiln. The buckets are of malleable iron, swung freely from a rod keeping the hot material away from parts to which heat could be damaging. Many cement mills are using this type of conveyor for this work and find it very satisfactory.

BUCKETS

Continuous Steel Elevator Bucket

We can supply various styles of continuous steel elevator buckets in various sizes and capacities, we can also furnish steel and malleable iron buckets for centrifugal discharge elevators.

WELLER MANUFACTURING COMPANY

1820-1856 N. Kostner Ave., CHICAGO

SALES OFFICES—New York Boston Baltimore Cleveland Pittsburgh San Francisco

PRODUCTS

Belt Conveyors (stationary and portable), Loading and Discharge Hoppers, Self-Propelling Trippers
Ask for Catalogue 35C

Bucket Elevators (belt and chain), Pivoted Bucket Carriers, Track Hoppers
Ask for Catalogue 35F

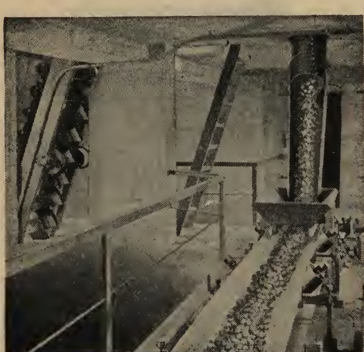
Weller Screens are Catalogued on Page 303 of this book.

SERVICE

This company designs and manufactures complete Elevating and Conveying Systems, as well as supplying any part of such equipment desired. Our catalogues show standard layouts, dimensions, capacities, and other data for the information of the operator in ordering.

Our engineering department is also at your service. Customers will do well to tell us just what they want to accomplish, and the surrounding conditions, and we will suggest the best installation to get the desired result.

Our equipment embodies many patented features not found elsewhere, and everything is thoroughly tested before leaving the factory.



Installation in Stone Crushing Plant

WELLER MADE CHICAGO

This stamp on your equipment insures service.

Weller Standard Elevators

WELLER STANDARD ELEVATORS

Buckets mounted on either belt or chain.

Built in standard stock sizes with buckets 9 in. to 36 in. wide with capacities ranging from 40 to 500 cu. yds. per hour.

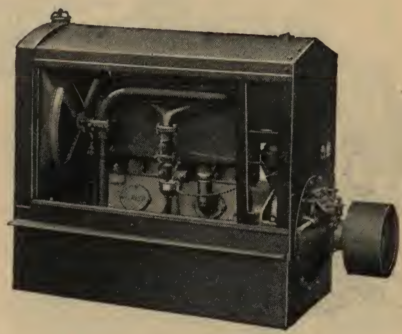
Buckets can be furnished in anything from No. 16 gauge to ¼ in. and ⅜ in. steel.

The timbers used vary in size from 2½x9½ in. on the smallest to 5½x15½ in. on the largest, all of the lumber used being the best grade of long leaf yellow pine.

For complete data see **catalogue 35F** sent on request.

BEAVER MANUFACTURING COMPANY

MILWAUKEE, WIS.

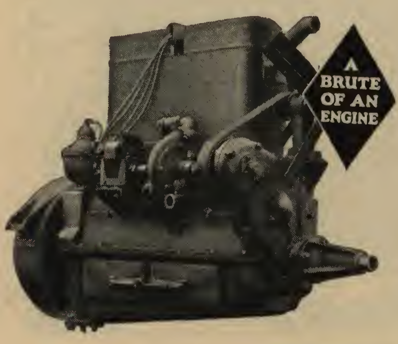


PRODUCTS

Engines (for tractors, trucks, cranes, mixers, compressors, hoists, ditching, road building and concrete machines). Power Units, fully equipped and ready to run with either clutch and pulley or speed reduction gear. Burn gasoline, kerosene and distillate.

Since 1902 Beaver has specialized on the production of automotive engines and you can get the benefit of our experience when a question about gasoline power arises. Just drop us a line and let us know about your requirements and it will be a pleasure for our Engineering Department to submit data.

Our new power unit has a Beaver, Brute of an Engine. That means it is big, capable and enduring. It is built for hard work and all the parts are big to give strength and long life.



Five models are available with a range from 15 to 60 belt horsepower. Trustworthy oiling and cooling systems are provided and in every way these units are engineeringly and practically right.

If you are using a belt drive you will be interested in our new clutch and pulley installation. You may require a speed reducer for a compressor or mixer, and if this is the case we will be glad to send you a layout covering a number of different ratios.

Detailed specifications covering the models will be sent on request.

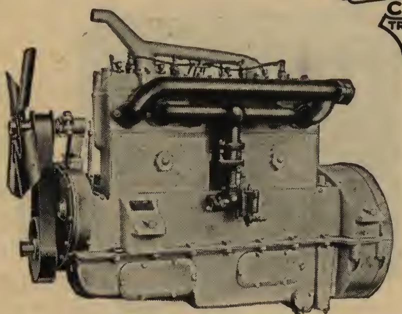
Model	ML	JA	JB.	RA
No. Cyls. . . .	4	4	4	4
Bore	3½	4½	4¾	5¾
Stroke	5	6	6	7
H. P. @ 800..	15	27	32.7	60
H. P. @ 1000..	20	35	38	..

CLIMAX ENGINEERING COMPANY

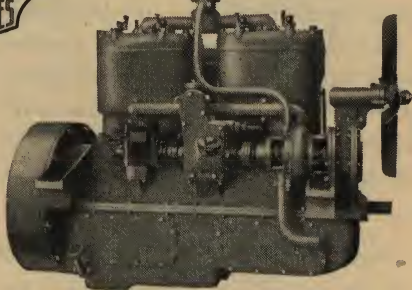
1805 South 4th St., CLINTON, IA.

MANUFACTURERS OF INTERNAL COMBUSTION ENGINES FOR AUTOMOTIVE AND INDUSTRIAL POWER PURPOSES

CLIMAX TRUSTWORTHY ENGINES



Model "KU" (5x6½)



Model "TU" (5½x7)

CLIMAX ENGINES

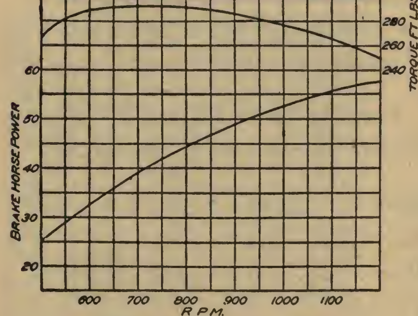
SPECIFICATIONS MODEL K AND KU*

Type—Four cylinder, vertical "L" head.
Size—Bore 5 inches, stroke 6½ inches.
Piston displacement—501.4 cu. in.
R. P. M.—800 Normal—1100 Maximum.
Weight—Model K, 1100 lbs. Model KU, 1150 lbs.
Horse Power—25 to 55 on gasoline.
20 to 45 on kerosene.

SPECIFICATIONS MODEL T AND TU*

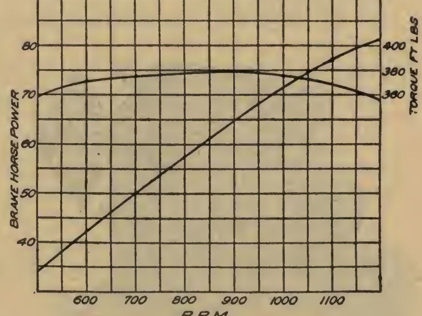
Type—Four cylinder, vertical "L" head.
Size—Bore, 5½ inches; stroke, 7 inches.
Piston displacement—665.2 cu. in.
Normal R. P. M.—750-800. Maximum, 1100.
Weight—1,150 lbs., fully equipped.
Horse Power—40 to 75 on gasoline.
35 to 55 on kerosene.

HORSE POWER AND TORQUE



MODELS K AND KU ON GASOLINE

*KU Engines equipped with flywheel housings for unit power plants.



MODELS T AND TU ON GASOLINE

*TU Engines have flywheel housings for unit power plant assembly.

ARNOLD & WEIGEL

WOODVILLE, OHIO, U. S. A.

PRODUCTS

(See page 275, this book.)

SERVICE

Contracting and Engineering.

Designers of Modern Lime Calcining and Hydrating Plants.

Detail plans and specifications.
(Ask for "Kil-o-grams".)

Estimates furnished.

Chemical analysis of limestones.

Practical burning and hydrating tests.

Reports, appraisals and special consulting work.

Being located in the heart of the lime producing center, we are constantly in touch with the latest developments which enhances the value of our services.

THE SCHAFFER ENGINEERING & EQUIPMENT CO.

2828 Smallman St., PITTSBURGH, PA.

PRODUCTS

Consulting, Designing and Supervising Engineers.
Schaffer Poidometers
Schaffer Continuous Hydrators.

See Page 274.

Present day conditions demand plants of simple, substantial and economical construction, and operation; the building of such plants for the manufacture of all products of the rock crushing and lime industries, is our specialty.

SCHAFFER SERVICE

Our service consists of designing plants to suit local conditions. Each plant with us is an individual proposition. We design new plants, large or small, complete in every detail; remodel and re-equip old plants; and design and redesign units of existing plants.

SCHAFFER PLANTS

Schaffer Crushing Plants produce maximum separations and mixtures, with less equipment.

Schaffer specially designed shaft kilns for calcining lime are producing the highest grade lime, and have the greatest capacity per dollar invested. Schaffer Rotary Kiln Plants are efficient and most flexible. They embody features for producing a wide variety of lime products.

Schaffer Hydrating Plants are marvels of simplicity and cleanliness.

The Schaffer Automatic and Continuous Hydrator is guaranteed to produce a higher grade hydrate than any other machine or process on the market.

Schaffer Plants produce different lime products without complications or added cost in manufacture.

Our engineers are at your service.

STEPHENS-ADAMSON MFG. CO.

AURORA, ILLINOIS

PACIFIC BRANCH FACTORY, LOS ANGELES, CALIF.

DISTRICT BRANCH OFFICES

NEW YORK, N. Y.	ST. LOUIS, MO.	CINCINNATI, OHIO
CHICAGO, ILL.	DETROIT, MICH.	PORTLAND, ORE.
BOSTON, MASS.	HUNTINGTON, W. V.	SALT LAKE CITY, UTAH
PITTSBURGH, PA.		

Designers and Builders of Complete Plants for Washing and Screening Sand and Gravel

COMPLETE SERVICE

S-A Engineers Design, Manufacture and Erect Complete Plants for the Washing and Screening of Sand and Gravel.

THE PRODUCT

Clean gravel is essential for the production of good concrete. Gravel must be thoroughly washed to remove the clay film which is present in bank-run material and which is detrimental to bonding qualities of any cement.

THE PLANT

S-A sand and gravel washing and screening plants are producing the highest grade concrete gravel with standard equipment. Each plant is designed in accordance with standards established after years of successful experience in this field.

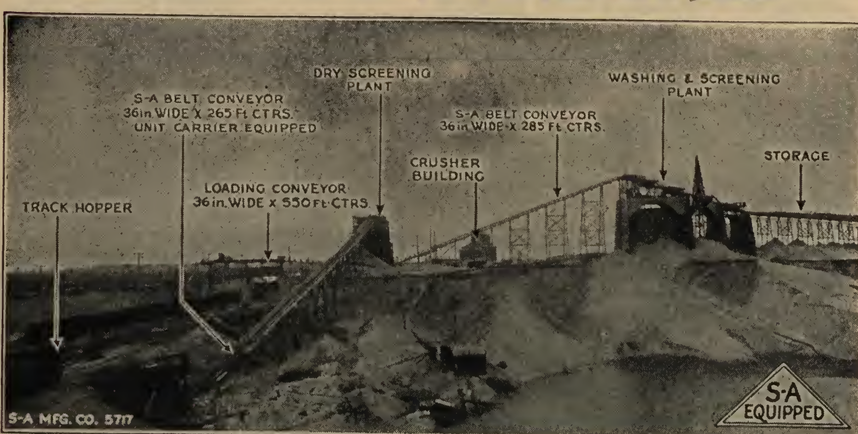
ENGINEERING COUNSEL

The design of each sand and gravel project presents new and important problems which must be given careful study by experienced technical men. S-A Engineers are designers of successful plants and their services are available to those contemplating new projects.

EQUIPMENT

Detailed information and prices may be furnished on S-A Belt Conveyors, Bucket Elevators, Screens, Scrubbers, Settling Tanks, Log Washers and other equipment for the modern washing and screening plant.

Call on an S-A Engineer in the nearest Branch Office. His assistance in selecting the correct machinery for your plant will be valuable.



One of the many plants of the United Fuel & Supply Co., Detroit, completely equipped with Stephens-Adamson Mfg. Co. machinery; plant located at Oxford, Michigan.

ATLAS POWDER COMPANY

WILMINGTON, DELAWARE

BRANCH OFFICES:

ALLENTOWN, PA.
BIRMINGHAM, ALA.
BOSTON, MASS.
CHARLESTOWN, W. VA.
CHICAGO, ILL.
DES MOINES, IOWA.
HOUGHTON, MICH.
JOPLIN, MO.
KANSAS CITY, MO.
KNOXVILLE, TENN.
McALESTER, OKLA.
NEW ORLEANS, LA.
NEW YORK CITY.
NORRISTOWN, PA.
PHILADELPHIA, PA.
PITTSBURGH, PA.
PITTSBURG, KANS.
POTTSVILLE, PA.
ST. LOUIS, MO.
WILKES-BARRE, PA.

ATLAS

Explosives for Quarrying

AMMITE

Cannot Freeze

The fact that millions of pounds of Ammite are used during the different seasons of the year is evidence of the efficiency of this non-freezing explosive as an all-year-round powder. Because it cannot freeze, Ammite eliminates the bother and expense of thawing. It also does away with powder headache when handling. It saves time and labor and cuts the cost of blasting. Ammite is made in various grades. Let the Atlas Service Man help you to determine what grade will save money for you. Write nearest branch.

ATLAS EXPLOSIVES AND BLASTING POWDER

Dynamite
Extra Dynamite
Gelatin Dynamite
Blasting Gelatin
Oil Well Explosive
Coalite (permissible)
Quarry Powders
Low Powders
Ammite (non-freezing)
Farm Powder
Non-Freezing Farm Powder
Stumping Special No. 2 L. F.
Blasting Powder
    "A" Blasting
    "B" Blasting
    (All granulations)
Fireworks Powder
Squib Powder
Black & Smokeless Powder

ATLAS BLASTING SUPPLIES

Fuse
Blasting Caps
Electric Blasting Caps
Delay Electric Blasting Caps
Delay Electric Igniters
Squibs
Electric Squibs
Cordeau-Bickford
Cap Crimpers
Leading and Connecting Wire
Blasting Machines
Sure Shot Shells
Tamping Bags
Kapseal
Rheostats
Galvanometers
Thawing Kettles
Storage Magazines (Portable)

E. I. DU PONT DE NEMOURS & CO., INC.

EXPLOSIVES DEPT., WILMINGTON, DELA.

For soft types of rock where no water is present, Du Pont Extra is more suitable than the quicker acting straight dynamites. Du Pont Extra is not classed as a low-freezing nor as a water-resisting dynamite.

Du Pont R. R. P. The lowest type of explosive as regards nitroglycerin content and is midway between blasting powder and dynamite. Rarely freezes in coldest weather but if it should freeze, it can be exploded provided the lumps are crumbled.

Blasting Powder. Slower in action and much less shattering than dynamite are the distinctive features about Blasting Powder. It is made in two grades—A and B. The A powder is made in six granulations, while B has seven. The finer granulations are quicker in action than the coarser. The action of Blasting Powder is of lifting and heaving nature and very little shattering effect is obtainable. Neither A nor B powders will resist water although A is a little more moisture resistant. Cold weather does not affect Blasting Powder.

The extensive and expensive preparations for blasting warrants the use of blasting accessories which are made especially for the work they are required to perform. Du Pont Blasting Accessories have acquired a very enviable reputation for reliability and efficiency. The steadily increasing demand is the best evidence of the satisfaction obtained by using them.

Du Pont Blasting Machines. These are designed to produce a sufficient amount of electricity to cause the proper action of the electric blasting cap, igniter or squib. Several sizes having variable capacities are made and brief descriptions follow:

Pocket Blasting Machine. This has a capacity of from one to three electric caps at one time. The handle is removable so that nothing can be done to generate current until the handle is placed in its position by the shot-firer. This is a "safety-first" feature which is quickly recognized. Where only a small number of shots are required, the Pocket Blasting Machine meets every requirement of the quarryman desiring to secure the benefits of electrical detonation of explosives.

Blasting Machines Nos. 3 and 4 will fire 30 to 50 Electric Blasting Caps. They weigh, respectively, 25 and 42 pounds. They are compact, thoroughly dependable and easily carried to the point of use. The No. 3 machine has sufficient capacity to meet the demands of the large majority of quarrymen.

Electric Detonaters. The electric blasting caps and igniters produced by the Du Pont Company can be depended upon to fulfill every requirement. The name "Du Pont" on the label of carton containing a blasting accessory is sufficient guarantee that the detonator will "fill the bill."

Galvanometers and Rheostats. For the detection of breaks in the wiring circuit, short circuits and points of high resistance, the Galvanometer is required. It is practically indespensable where electrical blasting methods are installed. The Rheostats are used for testing the capacity of the Blasting Machine.

Leading and Connecting Wires, Cap Crimpers, Blasting Caps, Tamping Bags and Other Accessories. We will be very much pleased to receive requests from users of explosives for a copy of our Blasting Accessories Catalog containing a complete description of these essentials for firing explosive charges. Besides describing the Accessories, there are many pages devoted to matters of interest to quarrymen. A copy of this book will be mailed promptly to you if request is sent to the Branch Office nearest to you and you state you have a copy of Pit and Quarry Hank Book.

HERCULES POWDER CO.

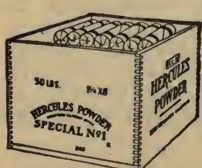
WILMINGTON, DEL.

ALLENTOWN, PA.
BIRMINGHAM
BUFFALO
CHATTANOOGA
CHICAGO
DULUTH
HAZLETON, PA.
JOPLIN
LOUISVILLE, KY.
NORRISTOWN, PA.
NEW YORK CITY
ST. LOUIS
PITTSBURGH, PA.
SALT LAKE CITY
SAN FRANCISCO
WILKES-BARRE
WILMINGTON, DELAWARE

PRODUCTS

Explosives and Blasting Supplies

HERCULES SPECIAL NO. 1



Because of its high cartridge count and low cost per cartridge, Hercules Special No. 1 is more economical on work for which it is suited than ordinary dynamite. There are about 1/3 more cartridges of Special No. 1 in a box than there are of ordinary dynamite in the same size cartridges. Hercules Special No. 1 frequently replaces 40% dynamite, cartridge for cartridge, at a saving of approximately 25 per cent.

HERCULES SPECIAL NO. 2

Hercules Special No. 2 is similar to Special No. 1, but is not quite as strong. Special No. 2 is usually more economical for blasting gypsum, clay, shale, and some of the easier-breaking rock formations. It has the same cartridge count as Special No. 1, but costs less per pound and per cartridge.

HERCULES NITROGLYCERIN DYNAMITE

Nitroglycerin Dynamite, commonly referred to as Hercules Powder, has been popular with users of explosives for many years. It is manufactured in strengths from 15% to 60%, is very quick in action, and fairly waterproof.

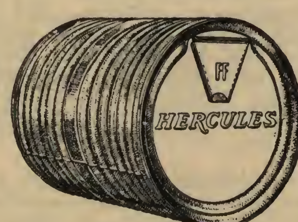
HERCULES GELATIN DYNAMITE

Hercules Gelatin Dynamite is distinguished by its plasticity, high density, imperviousness to water, and freedom from noxious fumes. It is made in strengths from 25% to 75%. It is good for wet work and for tight shooting in hard rock.

HERCULES EXTRA DYNAMITE

Hercules Extra (Ammonia) Dynamite is made in strengths from 15% to 60%. It is less expensive than Gelatin or Straight Nitroglycerin Dynamite. It is not as waterproof, but this is largely overcome by double dipping in paraffin.

HERCULES BLASTING POWDERS

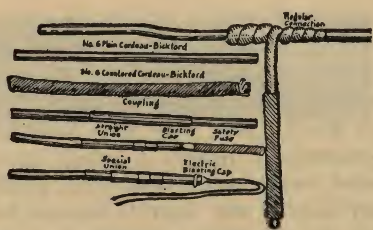


"A" Blasting Powder (or saltpetre powder) is for use in dimension stone, slate, and granite quarries. "B" Blasting Powder is used for general quarry work. A special granulation called R. R. is made for large blasts.

HERCULES POWDER CO.

BLASTING SUPPLIES

CORDEAU-BICKFORD



Cordeau is a lead tube filled with T.N.T. that detonates throughout its entire length, and is particularly effective in large charges of explosives. It is waterproof. Cordeau is wound on spools containing from 200 ft. to 500 ft. each, and may be shipped by express.

ELECTRIC BLASTING CAPS

These are made in two strengths, No. 6 and No. 8. They are furnished with insulated copper wires from 4 to 30 ft.; longer lengths on special order.

BLASTING CAPS

We do not recommend caps smaller than Hercules No. 6. Standard sizes Nos. 6 and 8. Packed 100 in a box, 5 to 50 boxes in a case.

FUSE

The Hercules Powder Company carries all standard brands of fuse. These are adapted to all kinds and conditions of work. Fuse is packed in coils of 100 ft. Cases contain from 5 to 60 coils.

BLASTING MACHINES

Made in three sizes. Hercules—Capacity, 50 electric blasting caps; Hercules No. 2—Capacity, 10 caps; Hercules Midget—capacity, 5 caps.

GALVANOMETERS

A reliable and compact instrument for testing electric blasting circuits, electric blasting caps, and for locating breaks, short circuits, faulty connections. Weight 1 pound.

RHEOSTATS

A small instrument offering the easiest and most effective means of testing the strength of a blasting machine without actually firing a series of electric blasting caps.

Write for our catalog of *Hercules Products* and a booklet on *Scientific Quarry Blasting.*

THE GRASSELLI POWDER COMPANY

MAIN OFFICE: CLEVELAND, OHIO

NEW YORK Office: 117 Hudson St.

PRODUCTS

Dynamite, Blasting Powder, Fuse, Caps, Electric Blasting Caps, Blasting Accessories

GRASSELLI EXPLOSIVES

There are many types of Grasselli Explosives made to meet all conditions in quarry and mine blasting. There are Grasselli Explosives of high speed detonation for various shattering effects and slow detonating explosives to give heaving and loosening effects.

Operators of quarries of the slope, pit and cliff type requiring different blasting effects will find a Grasselli explosive to meet these different requirements.

Grasselli explosives are of the gelatin nitro glycerine and ammonia dynamite types. All grades are low freezing, suitable for use in cold weather.

SERVICE

Grasselli offers you not only good explosives but also a genuine service, just as valuable as the high quality of the explosives.

There are eleven Grasselli branch offices, as follows:

Philadelphia, Pa. Pottsville, Pa.
Wilkes Barre, Pa. Pittsburg, Pa.
Bluefield, W. Va. Hazleton, Pa.
Clarksburg, W. Va. Chicago, Ill.
Cumberland, Md. Athens, Ohio
Birmingham, Ala.

Facilities at each of our many distributing stations assure fastest deliveries. Each station also has its practical field men. Grasselli field men are all men with wide practical experience in quarry blasting under varied conditions. We will gladly send one of our men to assist you with the blasting problems in your quarry.

BLASTING ACCESSORIES

The highest grade of Grasselli blasting supplies cost but a fraction of the price of explosives. By using Grasselli blasting supplies you are sure of the best results with relative safety to yourself and your men, and economic production.

Experience has proven electric blasting to be the safest, quickest, and most effective method of detonating explosives. The Grasselli Powder Company offers you a full line of electrical blasting supplies.

A. F. DAUM

PITTSBURGH, PA.

PRODUCTS

Refillable Cartridge fuse shells for electric light and power. Tested fuse strip.

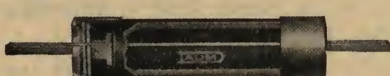
TYPE B REFILLABLE FUSE

3-60 Amperes—250-600 Volts

This fuse is refilled by removing both caps and one of the brass members supporting the fuse element. Insert the fuse strip through the slot in supporting member remaining in fuse, push through until it extends through the open end. Replace other supporting member, allowing the slot opening to slide over fuse element, bend over the ends of the strip, and replace caps. The entire operation consumes about ten seconds' time.

TYPE "E" REFILLABLE FUSE

65-600Amperes—250-600 Volts



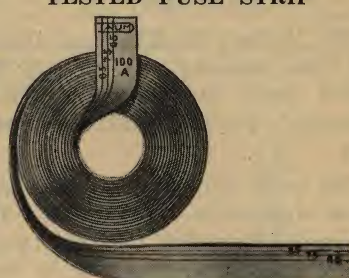
Only the proper fuse element can be inserted, thereby making over-fusing impossible. The fuse strip extends through the entire fuse, with the ends alongside the blades into the fuse-clips making a direct contact. This new DAUM Fuse consists of only six parts. Direct contact makes it impossible for any parts to fuse together. And the blown link can be removed and a new one inserted in TEN SECONDS WITHOUT TOOLS!

To refill—simply unscrew one ferrule and remove blade member. It is not necessary to remove other end, simply loosen ferrule. Insert fuse strip through slot in blade member remaining on fuse, and push it through fuse until it extends through open end. Replace blade member, allowing slot-opening to pass over the fuse strip, replace ferrule, and the fuse is renewed. Tested fuse strip is used.

FORM "7" REFILLABLE FUSE

Form "7" Semi-Inclosed Fuse is the simplest fuse that can be made. It consists of only two parts, the fibre tube and the fuse element, and can be renewed in five seconds without the use of tools. Are much safer than open link fuses, and more easily renewed. The cost is only a trifle. Tested fuse strip is used.

TESTED FUSE STRIP



Daum tested fuse strip is furnished in convenient rolls from 6 amperes to 600 amperes. Prices per roll are very low. Write for price list on Daum Tested Fuse Strip.

THE KRAMER BROS. FOUNDRY COMPANY

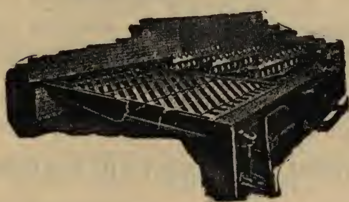
DAYTON, OHIO

PRODUCTS

McGinty Shaking and Dumping Grates, all styles and sizes of Grate Bars

Ask for Catalogue

McGINTY GRATES



In the designing of McGinty Shaking and Dumping Grates, the conservation of coal and the construction of a grate that would not warp under the terrific heat of the present day firing, were two of the paramount ideas kept constantly in mind. To build a grate that would successfully burn a very low grade of coal, and to prevent unburned coal from passing to the ash pit, has been our aim. That we have succeeded is being well proven by the performance of McGinty Grates.

CONSTRUCTION

The McGinty Shaking and Dumping Grate consists of a specially designed grate bar combined with a thoroughly practical shaking mechanism.

The grate bars are arranged in a series with truss bar supports. The design is such that the cross grate bars are set close together to burn coal of any degree of fineness without waste. The design also permits increased air space giving large supply of oxygen to the fire and keeping the trusses cool, thus preventing warping of the grate.

The shaking mechanism is a series of levers and arms that are controlled from in front of the fire box. An adjustable lug is fastened to the driving rod and is held in place by a latch bolted to the boiler front. This locks the grates in position and keeps them level.

The foot of the shaking mechanism is bolted to the boiler front near the floor level and to this is connected the shaker arm.

A crucible steel dog is connected to the lower end of the shaker arm, and rides in a notch cut in the foot. This notch allows four inches of motion, sufficient to sift out all ash and to keep clinkers broken up.

When it is desirable to completely dump the fire, the dog is tripped out of the notch. It is absolutely necessary to trip the dog before the fire can be dumped.

All shaker parts are adjustable to expansion and contraction.

When the fire is to be cleaned, it is only necessary to move the Shaker Rod a few times; there is no need to open the fire box door.

We also furnish grate bars and grate sections for all sizes and types as well as Repair Parts to fit automatic stokers.

A
Shaking
and
Dumping
Grate

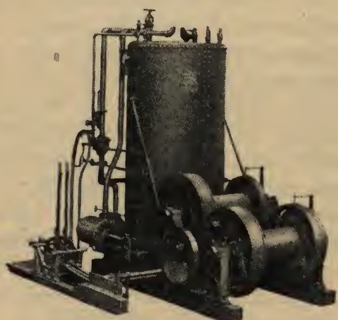
AMERICAN HOIST & DERRICK COMPANY

ST. PAUL, MINN.

BRANCHES—NEW YORK CHICAGO PITTSBURGH SEATTLE NEW ORLEANS

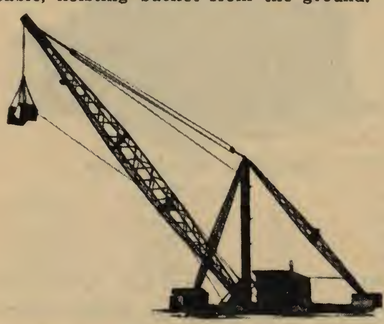
"AMERICAN" MATERIAL HANDLING MACHINERY

The machines shown below are just a fraction of our complete line, which includes locomotive cranes; wood and steel derricks of all types and capacities; a wide range of steam and electric hoists; blocks, sheaves and genuine "CROSBY" Wire rope clips. Tell us your handling problem and we'll help you pick the right machines.



"AMERICAN" Two Speed Hoist

Especially designed to get the most out of a slack-line drag-line excavator. This is a two drum engine with the front drum arranged for two speeds, there being a friction gear at either end. Front drum has power to pull bucket through material when filling and speed to "make time" to the hopper. Rear drum tightens main trolley cable, hoisting bucket from the ground.



"AMERICAN" Clamshell Stiffleg Derricks—Wood and Steel

"AMERICAN" Clamshell Derricks are made in a wide range of capacities. Scientific design, a large factor of safety and careful finish insure safety, smooth operation and long life. The accompanying picture shows a 10-ton "AMERICAN" Steel Stiffleg Derrick which was used with a 2-yard clamshell bucket to handle crushed rock. The derrick has a 90-foot boom and a 40-foot mast.

"AMERICAN" Heavy Duty Clamshell Derrick Engine

Double cylinder, three friction drum hoist operates boom, holding and closing lines. Independent slewing engine swings boom. 9x10 size handles 1½ yard bucket; 10x12 handles a 2-yard bucket. Cool running expansive frictions with woven wire asbestos fabric friction facing. Boiler furnishes ample steam for hoist and independent slewing engine.

"AMERICAN" Independent Slewing Engine

The "AMERICAN" Independent Slewing Engine takes steam from the hoist boiler. All motions are controlled with the throttle lever. No slewing brake is required. Always under full control; starts and stops smoothly. Can be placed right beside the hoist or operated with a lever in a lever bank.

TREADWELL ENGINEERING COMPANY

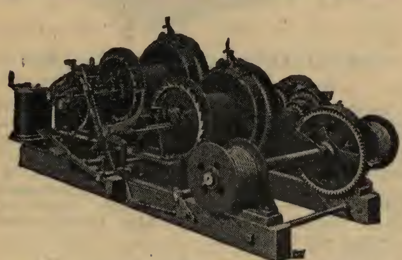
EASTON, PENNA., U. S. A.

PRODUCTS

Steam and Electric Hoists, Cableways, Rubbing Beds, Stone Working Machinery, Iron Castings, Electric Furnace Steel Castings, Mine and Quarry Cars, Rope Drives, Hoisting and Haulage Drums, Gears—Moulded or Cut Teeth, Rolling Mill Machinery, Pipe Cutting, Threading and Bending Machines, Sheave Wheels, Special Machinery.

STEAM AND ELECTRIC HOISTS

Treadwell Steam and Electric Quarry and Contractors' Hoists embody many novel and distinctly advantageous features in hoist design.

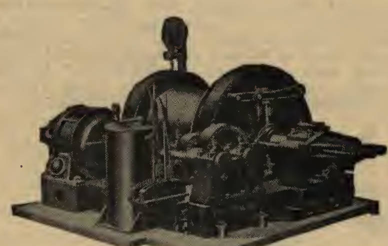


Treadwell Contracting Hoist Type CDS

TREADWELL HOISTS, through the excellence of the engineering which has evolved their design and the maintenance of the same high standard throughout their manufacture, have definitely established themselves as HOISTS OF A BETTER GRADE.

The Treadwell Line of Hoists is outstandingly modern. It has been developed without the handicap of tradition, or the inheritance of features whose major excuse for repeated use lay in the desire that the investment in pattrns, jigs, etc., made for earlier models need not be duplicated. Though newly conceived to bear the Treadwell name, these hoists are built on basic ideas which have been tested and provn by years of service.

The basic features underlying the design of Treadwell "Heavy Duty" Hoists are: utmost simplicity,—making same easy to erect and adjust; correct distribution of metal—producing a balanced mechanism and ability of all members to resist strain; and mechanical dependability. Gray cast iron, box type frame; cast steel or semi-steel gears with machine cut teeth; cast iron or sheet steel drum, brakes lined with hardwood or asbestos—no cast iron used in brake mechanism; all controls in easy reach.



Treadwell Electric Hoist Type MS

The TREADWELL QUARRY HOISTS are equipped with special double-toggel band type friction clutches (Werner Patent) and are operated mechanically or by hand.

The Company will supervise erection and unreservedly guarantee against breakage under normal service for one year.

TREADWELL ENGINEERING COMPANY

Types: Treadwell Hoists are built in different types: MS—Single friction Drum, Single Brake; MD—Single Friction Drum, Double Brake; MG—a single drum, two speed friction drive with single or double brake; MC—a double drum hoist, direct drive, post brake; MT—a tandem drum hoist, friction drive, single or double brakes; CS—a single friction drum, contractors' hoist; CD—a double friction drum, Contractor's Hoist, single brake; CT—a three tandem friction drum, contractors' hoist, and PH—a single drum, completely enclosed portable drum hoist.

Treadwell Electric Handy Hoist Type PH

Type MS—Single Drum Friction Drive—Single Brake

			DIMENSIONS—INCHES				
Size No.	Average Rope Pull Pounds	Electric Motor H. P.	Width A	Length B	Height C	Diam. of Drum D	Width of Drum E
1-MS	7,500	100	100½	99½	62 11/16	42	36
2-MS	10,000	150	123⅛	118½	67¼	48	42
3-MS	15,000	225	142⅛	134⅛	78½	54	48
4-MS	20,000	300	144	145½	85	60	60
Type MD—Single Drum Frictional Drive—Double Brake							
1-MD	7,500	100	107⅜	99½	62 11/16	42	36
2-MD	10,000	150	131⅞	118½	67¼	48	42
3-MD	15,000	225	149⅞	134⅛	78½	54	48
4-MD	20,000	300	153¼	145½	85	60	60
Type CDS—Double Drum—Contractors' Hoist—Swinging Gear							
1-CDS	2,500	18	45	119	53	12	18
2-CDS	4,000	28	50½	127	61	12	20
3-CDS	6,500	45	62½	149	70	14	26
4-CDS	10,000	72	72	171	76	16	30
Type PH—Single Drum—Enclosed—Portable Room Hoist							
PH	1,500	5	24	54	24	8	12

Motor horsepower rating has been based on a rope speed of 400 feet per minute, for types MS and MD—200 feet per minute for type CDS, and 100 feet per minute for type PH.

Write for complete Specifications and Prices to meet your exact conditions.

THOMAS ELEVATOR COMPANY

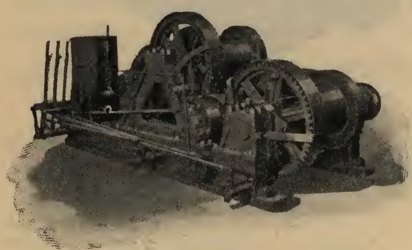
21 South Hoyne Avenue, CHICAGO

PRODUCTS

Hoisting Machinery

THOMAS TWO SPEED ELECTRIC HOIST

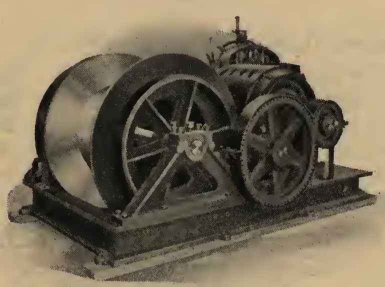
Designed for dragline cableway operation. Equipped with the Thomas



Band Friction which operates without a thrust bearing of any kind.

THOMAS INCLINE HOIST

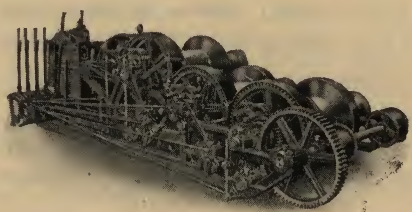
A single drum hoist of the band friction type extensively used for incline work, car haulage, etc. Built



in various sizes ranging from 15 to 300 horsepower.

THOMAS BAND FRICTION THREE DRUM HOIST

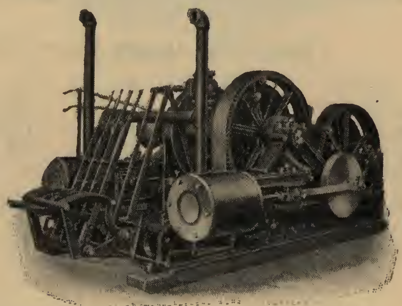
For clam shell and grab bucket work. Illustration shows machine equipped with attached swinger, but is also



furnished in three drums with independent boom swinger.

THOMAS DOUBLE DRUM STEAM HOIST

Made in both single and two speed types for dragline cableway operation



and scraper work. Band frictions used exclusively.

THE CINCINNATI RUBBER MFG. CO.

CINCINNATI, OHIO

PRODUCTS

Transmission Belting
Conveyor and Elevator Belting
Sand Suction Hose and Dredge Sleeves
Air Hose
Steam Hose
Water Hose
Sheet Packing both Rubber and Fibre
Piston Packing of all kinds
Pump Valves

SUCTION HOSE

Sandow Sand Suction Hose is the result of years of practical experience in building suction hose, during which time we have devoted special attention to the manufacture of hose for sand and gravel plants.

Our Sandow Sand Suction Hose is made extra heavy and over-size for the entire length thereby eliminating the weakness of enlarged ends.

ARNO DREDGE SLEEVES

Made of heavy strong duck, heavily frictioned, and with a tube of extra tough material that will resist the cutting and abrasive properties of the materials passing through them. Yet this construction is not so heavy as to impair their flexibility.

We will be glad to answer your questions and to send further details.

PHOSPHATES FLEXIBLES

We embody in the construction of Heavy Suction hose of this character certain features that as far as we are able to learn are not known or used by other manufacturers.

AIR DRILL HOSE

Losant Air Drill hose is built along entirely different lines from other grades in common use. Heavy duck is used in all sizes, with high grade tubes and extra heavy cover stocks of the finest material. This hose is sold regularly without armor, as the quality and thickness of cover stock is sufficient protection against cutting while being dragged over sharp, rough surfaces.

BELTING

Our Pacemaker Transmission Belting is made of especially woven heavy duck impregnated with a pure gum friction or bond between the plies and is designed for very severe service such as crushers, etc.

Conveyor and elevator belting to meet any conditions.

THE SCHAFFER ENGINEERING & EQUIPMENT CO.

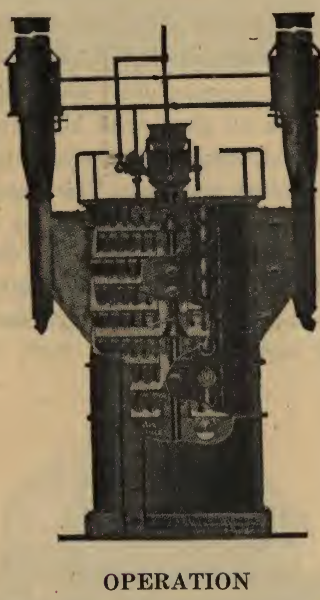
2828 Smallman St., PITTSBURGH, PA.

PRODUCTS

Schaffer Continuous Hydrator
Schaffer Poidometer
Consulting, Designing and Supervising Engineers
See Page 259.

THE SCHAFFER HYDRATOR

The Schaffer Hydrator is a machine built to hydrate lime in an automatic, continuous manner, and to produce the required conditions for obtaining the highest results in transforming quicklime into hydrate.



OPERATION

The action of the Hydrator being continuous and automatic, quicklime is fed into the top of the Hydrator by a Schaffer Poidometer, a mechanical marvel which weighs the lime, adds the proper quantity of water, and eliminates entirely the guesswork of human labor. The exact proportion imperatively necessary before good hydrate can be produced, is thus quickly and surely obtained.

The lime is distributed in even layers and water so sprayed as to come in contact with every part of the lime at the proper time.

The mixing action is most thorough and complete. In this is utilized a furrowing action, working against centrifugal force, and the same action in conjunction with centrifugal force alternately. This can be controlled to suit conditions and the nature of the quicklime.

The product of the Schaffer Hydrator is uniform. It will take more water than ordinary hydrate, has retained all of its beneficial elements, and has greater plasticity. It contains no particles of lime which are not completely hydrated.

Either high calcium or dolomite lime can be handled with complete success.

By reason of perfect control of air and gases and ample capacity in cooling section, the lime, when delivered to finish mills, is cool and dry.

The construction of the machine itself embodies the best material and workmanship procurable. This machine is designed to eliminate repairs so far as possible, every working part being so constructed as to insure heavy duty.

Schaffer Hydrators are made for both large and small plants.

See page 257, this book.

STEACY - SCHMIDT MANUFACTURING CO.

YORK, PENNA.

CABLE ADDRESS—"BROOMELL," YORK, PENNA.

Manufactuers of Lime Kilns, Sugar, and Special Machinery

PRODUCTS

Keystone Lime Kilns, complete Lime and Hydrating Equipment for Lime Burning

Also Manufacturers and Designers of Sugar Machinery, Filters, Stacks, Tanks, Gray Iron Castings, Pulverizing Mills and Machine Work from Engineers' Designs

ENGINEERING SERVICE

While the Keystone Kiln is the main unit in a hydrating plant, our engineers are in a position to design and supervise the construction of the entire hydrating plant.

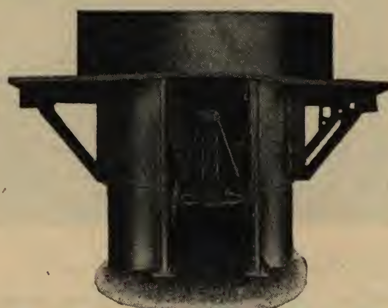
Keystone Lime Kilns

The Keystone Kiln is the result of kiln practice extending over many years of experience. This kiln is of all-steel, brick lining construction, built of heavy steel boiler plate to give the strongest possible construction. It is arranged to burn coal, wood, gas, or oil as fuels. The special features of this kiln allow continuous operation, the rock being supplied at the top through a feed cone and drawn off through the cooling cone by drawing shears.

Sectional View Keystone Lime Kiln.

CAPACITY

The capacity of lime kilns and the cost of burning are dependent upon a large number of variables, such as the nature and quality of the rock, kind of fuel used, together with the management and skill of the burners. It is therefore impossible to predict the exact amount of lime that can be obtained from a given kiln; however, under average conditions with a standard kiln burning coal or wood, 9 to 14 tons per day may be produced. If forced or induced draft is used, these figures are exceeded. With producer gas or oil as fuel, the capacity ranges from 14 to 25 tons per day.



View showing Keystone Kiln set at right angles to Drawing Shears.

SPECIFICATIONS

The standard kiln has an outside diameter of 11 ft.; diameter of brick lining 6 ft. 6 in.; total height of kiln, 47 ft. 10 in. Shipping height, about 42,500 pounds.

GENERAL

Our pattern, foundry, machine and boiler shops have been recently remodeled and equipped with the latest tools and machines, and are able to produce economically gray iron castings, stacks, tanks, boilers, sugar machinery, dryers, pulverizing machinery, elevators, bins, conveyors, and special machine work from engineers' designs constructed in exact accordance with specifications.

CARBIC MANUFACTURING CO.

DULUTH, MINN.—301 Central.
NEW YORK, N. Y.—141 Centre St.
CHICAGO—565 W. Washintogn Bldv.
BOSTON—27 School St.

PRODUCTS

Portable Acetylene Lights
Welding & Cutting Apparatus (Oxy-Acetylene)
Generators and Supplies
Carbic Generator—All kinds
Carbic Cakes (Briquetted Carbide)

CARBIC LIGHTS

Carbic lights represent the highest development in powerful, portable lighting equipment and have proven by practical use on quarrying, construction and emergency operations from coast to coast, that they meet every requirement of a portable light, the essential qualities of which are efficiency, portability, economy and simplicity—coupled with absolute safety.

The burners are storm proof, smokeless and produce a flame free from sparks.

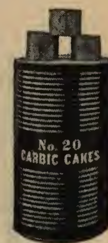
Because Carbic lights consist of but three parts, charging may be done in very few minutes by the most inexperienced labor.

Passed by Fire Underwriters Laboratories.

CARBIC CAKES

Carbic cakes, used in all Carbic lights, are made from the highest grade calcium carbide treated and compressed into briquet form, and are truly the most efficient and economical means of supplying gas for portable lights.

The Carbic system of generating from the Carbic cake insures a purity of gas, a brilliance of flame, a uniformity of candle power and a safety not otherwise obtainable.



WELDING & CUTTING

The Carbic line of oxy-acetylene welding and cutting equipment is complete, including torches, generators, regulators, etc.

The Carbic portable generator, although of small size and light weight, is substantially constructed throughout and has a producing capacity sufficient to make it thoroughly suitable for use on a wide range of work. Listed as standard by Fire Underwriters' Laboratories.

The advantages of generating acetylene from Carbic cakes, for use in welding and cutting, are many—ask us for further information.

THE GEORGE HAISS MFG. CO., INC.

EAST 142ND ST. & CANAL PLACE, NEW YORK

Sales Offices in Principal Cities

PRODUCTS

Truck and Wagon Loaders
Portable Belt Conveyors
Clamshell Buckets
Plant Equipment

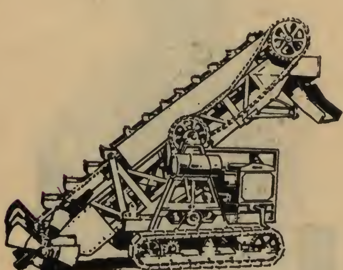
Known and identified by the sign

HAISS "CREEPER" LOADER

The most powerful and efficient machine of its kind. It will dig and load 1½ cubic yards per minute. It is self-propelling in both directions, is equipped with Haiss positive self-feeding propellers and has a slow speed drive which can be brought into play while the elevator is working. This slow speed drive keeps the machine "crowded" against the pile so that every bucket is heaping full.

Driven by 37 H.P. Waukesha Motor and mounted on caterpilar treads that take the machine over any ground. Sturdily built and of the best material in every part.

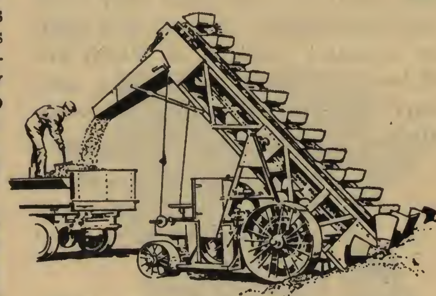
The ideal machine for loading from a sand or gravel bank. Widely used by road contractors, quarry men, etc., for handling crushed stone and sand from stockpiles. First choice for heavy duty work of any kind.



Haiss "Creeper Path Digging" Truck Loader

"PATH DIGGING" LOADER

A standard wheel mounted machine which has all the automatic motions of the Creeper type, but slightly smaller and with a capacity of 1 cubic yard per minute. This type is furnished with a 24 H.P. Waukesha Motor, and can be had wtih a high elevator for discharging into very high trucks or into cars.



Haiss "Path Digging" Truck Loader

One man only is required to operate these machines—there is no trimming, the self-feeding device does all the work.

The "Path Digging" Loader is recommended for any personal service where its wheel mounting is no handicap. Extensively used and standard equipment in material yards and with rock products producers.

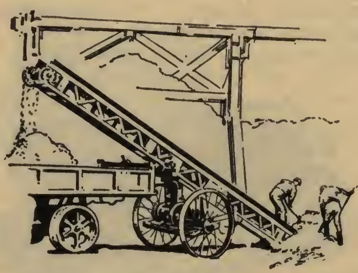
OTHER SIZES

The Company also builds standard loaders in a wide range of types and capacities—a machine for every duty.

THE GEORGE HAISS MFG. CO., INC.

PORTABLE BELT CONVEYORS

Haiss Portable Belt Conveyors are outstanding machines in their class. They are built to a standard of engineering excellence that marks them as equipment for Better Service. Thanks to the care taken in designing and building them, they will do more work, at lower cost, over longer periods than is possible with low cost units.



Haiss Portable Belt Conveyor

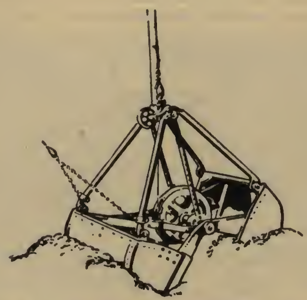
Built both electric motor and gasoline engine driven in a complete range of sizes from 20 to 60 feet in length, and 14 to 24 inches in width. You can have either a hand or power propelled unit, or one revolving on its chassis. Capacities 40 to 100 cubic yards per hour.

CLAMSHELL BUCKETS

Haiss Buckets are the kind that experienced operators use. Built strong and heavy—with husky steel castings, drop-forged connecting rods, rigid bracing and thick steel plate. They stand the gaff.

Haiss "Contractor" Buckets of the power wheel type are built in standard sizes from ¼ to 2 cu. yards capacity. They are in general use for rehandling at quarries, sand pits and material yards.

Haiss "High Power" Buckets are built for excavating and heavy digging in sizes from ½ to 3 cu. yards capacity.

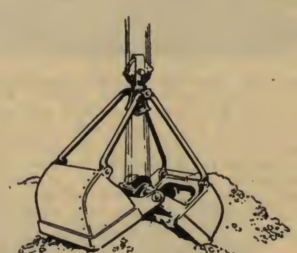


Haiss "Contractor" Clamshell Bucket

PLANT EQUIPMENT

Haiss also makes plant equipment and carries stocks which enable the Company to render real service to the operator who needs

- Bucket Elevators
- Flight Conveyors
- Revolving Screens
- Hopper Gates
- Elevator Parts, Chain, etc.



Haiss "High Power" Clamshell Bucket

LITERATURE

We will be glad to send copies of any of the following Bulletins

Creeper Loaders	521
Path Digging Loaders	621
Belt Conveyors	1022
Clamshell Buckets	719
Plant Equipment	619

BROOKVILLE TRUCK & TRACTOR CO.

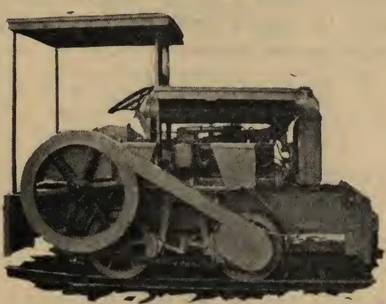
BROOKVILLE, PA., U. S. A.

PRODUCTS

Locomotive Attachments for Ford Ton Trucks and Fordson Tractors.

Ask for Catalogue

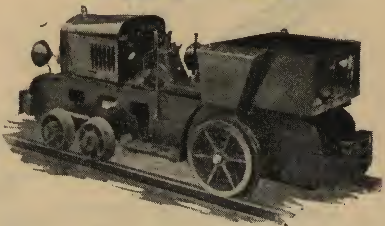
Thru the use of Brookville Locomotive Attachments



6,000 lbs. weight—1,500 lbs. draw bar pull—4 wheel drive—20″ drive wheels—36½″ wheel base, suitable for the sharpest curves—6 mile working speed, both forward and reverse; no necessity of turntables or "Y's"—Equal to any three to four ton gas locomotive on the market, at a fraction of the cost, plus all the advantages of local Fordson Service—Will do the work of from four to six horses or mules.

Furnished complete with Fordson, or merely the locomotive attachments, as desired—No mutilation of Fordson.

All gauges 24″ to 56½″



For the lighter operations the Ford Ton Truck with Brookville Locomotive Attachments. The most practical, efficient and economical power known. The Brookville Reverse gives the Ford truck high and low speeds in both forward and reverse work. Will handle from 2 to 20 tons to trip, according to grade and track conditions, and readily make four round trips hourly over one half mile of track.

All gauges 24″ to 56½″

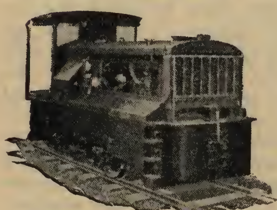
Regardless of what haulage you are now using or intend to use, get the facts from Brookville.

THE FATE-ROOT-HEATH CO.,

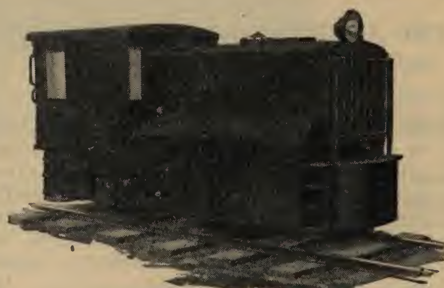
PLYMOUTH, OHIO

PLYMOUTH
Gasoline Locomotives

Friction and Gear Driven



4 Ton Friction Drive



7 Ton 4-Speed Gear Drive

FOR YOUR INDUSTRIAL HAULAGE

PLYMOUTH Gasoline Locomotives are manufactured in both friction and gear driven types, and in sizes from three to seven tons.

The number now in use is greater than all other similar types combined, which fact is proof of PLYMOUTH utility and durability.

We have bulletins covering a dozen industrial fields and each replete with interesting photographic performance views. Will mail on request.

Plymouth Locomotives at Brokensword Stone Co., Bucyrus, Ohio

THE HADFIELD-PENFIELD STEEL CO.

BUCYRUS, OHIO, U. S. A.

PRODUCTS

American Gasoline Locomotive, Rigid Rail Crawler for quick attachment to Fordson Tractor, "Era" Manganese Steel Repair Parts for Steam Shovels, Crushers, Gears, Chain and Sprockets, Cement Machinery, Clay Products Machinery.

Write for our catalogues.

THE AMERICAN GAS-O-MOTIVE

The American Gasoline Locomotive is built in two types—mining or low down type and standard or cab type. It is built for economical service, is simple in design, trouble-proof and easy on gas.

CONSTRUCTION

We call particular attention to the massive, well finished frame of the American. It extends the entire length and full width of the locomotive and is built to withstand shock and strain. With its properly balanced weight close to the rail it gives maximum traction.

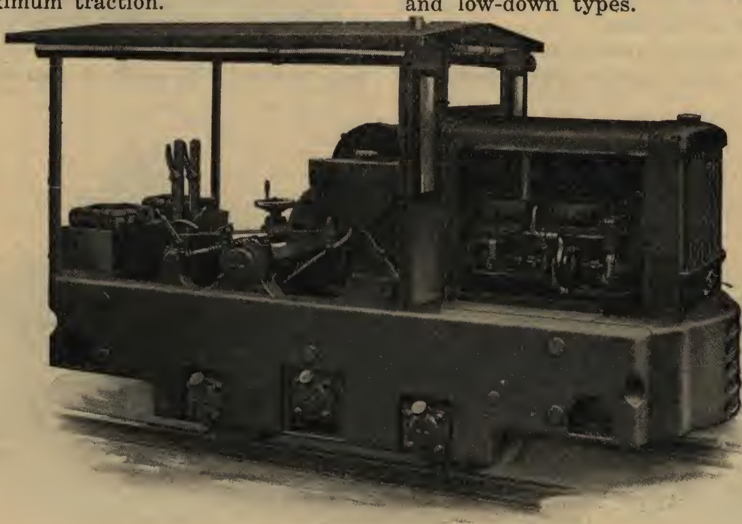
The American is equipped with a Hercules motor of the Heavy Duty type, giving the locomotive ample power at a reasonable speed. It is a five main bearing motor with full force oil feed, oil being forced even to the piston pins. The motor has a detachable head and is so constructed that it can be overhauled with a minimum of labor.

The American Gasoline Locomotive uses the Flexible Thermoid Coupling enclosed in Bell Housing. This Bell Housing, which also encloses the fly wheel of the motor, is mounted on lugs, cast on the inside frames and assures perfect alignment of the transmission at all times. Hyatt Bearings are used on the axles.

Special attention has been given to the sanding arrangement, sand boxes are under the canopy of the locomotive out of the rain, and the sanding pipes are so placed as to give a supply of sand at each wheel on the rail.

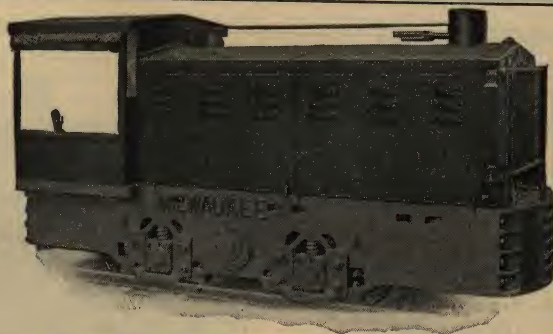
The American provides ample brakes to all four wheels. They are most effective as we consider a good braking system of utmost importance.

American Gas-O-Motives are built in sizes from 3½- to 7-ton—standard and low-down types.



MILWAUKEE LOCOMOTIVE MFG. CO.

Belleview Place & River, MILWAUKEE, WISCONSIN, U. S. A.



F-30 6-Ton, Four Speed Gear Drive Locomotive.

MILWAUKEE GASOLINE LOCOMOTIVES FOR QUARRY AND GENERAL INDUSTRIAL HAULAGE

Milwaukee Gasoline Locomotives are the modern motive power for quarry and general industrial haulage. They are scientifically correct in design, sturdy in construction and absolutely reliable and economical in operation. They are built in a variety of types and sizes, for all gauges of track, and are sold on a positive guarantee based on actual performance.

Type "F-30," 6-ton, 4-speed, gear-drive locomotive, is without doubt the last word in locomotive design and construction, with speeds from 2.75 to 12 miles per hour, both forward and reverse.

Regularly furnished with steel cab and curtains and electric lights and starter. A most sturdy, flexible and economical locomotive, absolutely reliable in operation, that is especially well adapted for quarry and industrial haulage.

Type "W" locomotives are built in 2½-, 3- and 3½-ton sizes, and can be furnished with canopy top and electric lights and starter when specified.

The type "W-10" and "W-20," 2½ and 3-ton locomotives, are geared for one speed of 6 miles per hour and the WA-20 3½-ton locomotive has 2 speeds of 4 and 8 miles per hour, both forward and reverse.

Extensively used for quarry and industrial haulage, where conditions require only a medium weight machine.

It places you under no obligation to have our engineers make a study of your own particular haulage requirements and, with you, complete a real solution of your haulage problem. Write for catalogs V-121 and V-126.

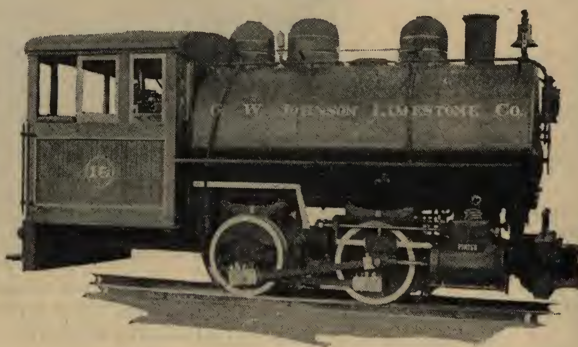
Milwaukee Type "W" Locomotive in Quarry Haulage Service.

H. K. PORTER COMPANY

LOCOMOTIVE BUILDERS

PITTSBURGH, PENNA.

Where the output of a pit or quarry is dependent on one or two locomotives it is most important that such machines be designed and built to withstand continuous hard work over the rough track and around the sharp curves usually encountered in such service.



PORTER LOCOMOTIVES

are especially built to stay on the job every minute. A few sizes of PORTER Class B-S medium weight four-wheel-connected-saddletank locomotive are described below.

CODE WORD	KITTEL	KITTIM	KIZLOZ	KLADDE	KLAMST
CYLINDERS { diameter, inches	9	10	10	11	12
CYLINDERS { stroke, inches	14	14	16	16	16
Diameter of driving-wheels, inches	27	30	30	31	33
Wheel-base, feet and inches	4-6	4-6	5-0	5-0	5-0
Length over bumpers, feet and inches	16-8	16-9	18-3	18-3	19-8
Extreme height (head-room not limited), feet and inches	9-0	9-3	10-0	10-0	10-9
Weight in working order, all on driving wheels, pounds	29,000	32,000	37,000	42,000	47,000
Water capacity of saddle-tank, gallons	450	550	650	750	800
Fuel capacity, coal, lbs	350	600	600	600	800
Weight per yd. of lightest rail advised, lbs.	30	35	35	40	45
Radius of sharpest curve advised, feet	35	35	45	45	45
Radius of sharpect curve practicable, feet	30	20	25	25	25
Boiler pressure per square inch, lbs	170	170	170	170	170
Tractive force, pounds	6,070	6,750	7,710	9,020	10,080
Factor of adhesion	4.77	4.75	4.80	4.66	4.66
Hauling capacity, in tons of 2,000 lbs. (exclusive of locomotive), good average cars and track, 10 lbs. per ton resistance of rolling friction.					
On absolute level	590	655	750	880	980
On ¼% grade= 13 2/10 ft. per mile	390	430	495	580	645
On ½% grade= 26 4/10 ft. per mile	285	320	365	430	480
On 1 % grade= 52 8/10 ft. per mile	185	205	235	280	310
On 2 % grade=105 6/10 ft. per mile	105	115	135	155	175
On 3 % grade=158 4/10 ft. per mile	70	80	90	105	120

A good assortment of sizes and gauges of this design is always on hand for immediate delivery

GEO. D. WHITCOMB COMPANY

ROCHELLE, ILLINOIS, U. S. A.

PRODUCTS

Whitcomb Gasoline Locomotives
Whitcomb Electric Locomotives

Write for our catalogues

WHITCOMB LOCOMOTIVES

In 1906 our first gasoline locomotive was installed and was the first successful locomotive built in this country. The fact that it is still in successful operation demonstrates the ability of Whitcomb equipment.

We later developed an equally successful electric locomotive.

WHITCOMB GASOLINE LOCOMOTIVES

Whitcomb Gasoline Locomotives are built in all sizes, from two to 25 tons on the drive wheels, and in gauges from 18 to 60 inches.

Power is furnished by a Type "EU" Waukesha motor, which is one of the best tractor type engines built today. All parts of the engine are oiled by a force feed system. The cylinders are of the removal head design. The cooling system is handled by a rugged centrifugal pump and is so arranged that the entire system may be drained from one point. The governor is of improved type, adjustable as to speed, sealed, self-lubricating and non-hunting.

Ignition includes Aero type Dixie magneto, equipped with an adjustable coupling and impulse starter coupling making cranking easy.

The clutch is made in our own factory, and is of excessive capacity and of the very latest design. It is easily operated, is equipped with an improved spinning brake and runs in oil.

Transmission is of the selective gear type, permitting four speeds in each direction. The speed variation is controlled by a speed change lever having also a neutral position. All of the gears, pinions and sprockets in the transmission are chrome vanadium drop forgings carefully machined and heat treated. All like parts are interchangeable. The case is built to allow free access and so constructed that all parts run in oil.

The axles are made of forged steel carefully machined and are carried on heavy duty ball bearings. The wheels are rolled steel. The main frame is of heavy cast iron, thoroughly braced and ribbed.

WHITCOMB ELECTRIC LOCOMOTIVES

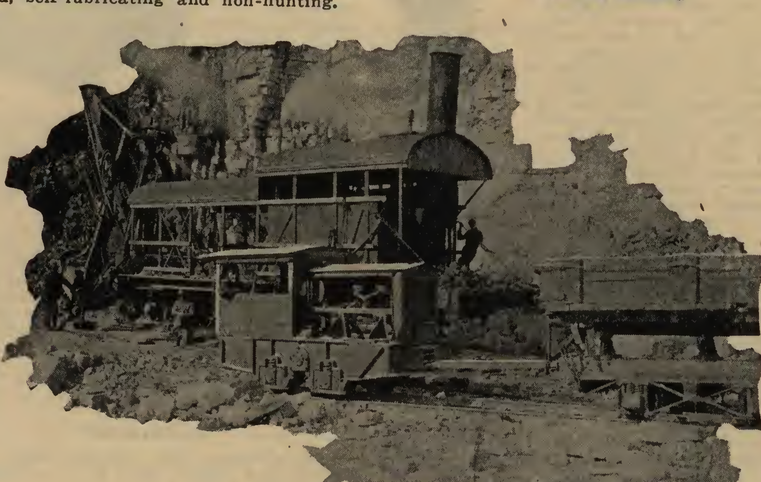
Whitcomb electric locomotives are built with the same care and excessive strength as our gasoline locomotives. Motor, battery box and controller are of our own make and are built along the most improved lines. Axles are of M. C. B. specification steel and the worm gear made by the Timken Detroit Axle Co. Our bulletin 2210 gives detailed description.

DESIGNED TO WORK

WHITCOMB LOCOMOTIVES

GASOLINE STORAGE BATTERY TROLLEY COMBINATION

BUILT TO OVERWORK



THE VAN DORN IRON WORKS COMPANY

2685 East 79th St., CLEVELAND, OHIO

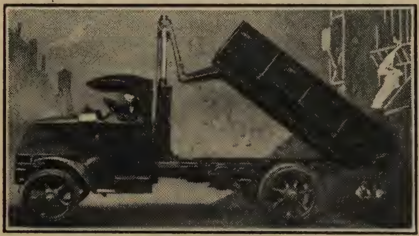
BRANCHES: CHICAGO, PHILADELPHIA, LONG ISLAND CITY, PROVIDENCE

Distributors in all other principal cities

PRODUCTS

Van Dorn Mechanical Dump Truck Body Hoists (Vertical and Horizontal Types), Van Dorn Dump Truck Bodies (standard and special built) in steel or composite wood and steel; Van Dorn Truck Frames and Pressed Steel Parts.

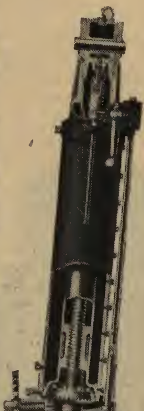
Van Dorn Mechanical Horizontal Hoist and Standard Steel Body.



Van Dorn Mechanical Vertical Dump Truck Hoist and Standard Steel Body

VAN DORN VERTICAL TRUCK HOIST

The cutaway view of the Van Dorn Mechanical Vertical Dump Truck Hoists shows the screw jack principle of operation and the automatic lubricating device. The hoist is operated by lever reached from the driver's seat. The plunger which is connected to the body by ⅝ in. steel cables is raised and lowered by the rotation of the heavy screw jack. This hoist is speedy in operation, positive in control of the body and immune from all weather troubles. The heaviest load can be stopped, locked at or lowered from any angle up to 45°, the automatic stopping point. The truck can be driving away while the empty body is lowering, the hoist disengaging and stopping as the body settles to its bed.



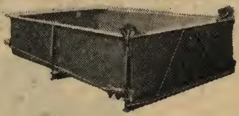
AUTOMATIC LUBRICATION

An automatic oiling device distributes a measured shot of oil to all working parts of the hoist at every operation. This minimizes wear, saves oil and insures long life. The only attention needed is an occasional filling of the oil reservoir.

VAN DORN HORIZONTAL TRUCK HOIST

The cutaway view of the Van Dorn Mechanical Horizontal Dump Truck Hoist shows the arrangement of worm and spur gears which transmits the power developed by the truck motor to end dump, side dump or directly elevated the body. The connection between hoist and body is made by a link and lift arm to give the highest dumping angle and allow a 'jack-knife" folding of the arms when body is lowered.

VAN DORN TRUCK BODIES



We have no hesitancy in claiming Van Dorn Truck Bodies to be the strongest built. Van Dorn bodies are built-up steel bodies. They are fabricated, riveted, welded and reinforced to withstand the most ponderous loads and impacts of tons of rock or slag dropped by steam shovel or bucket. Built in regular standard models or made to specifications.

SERVICE

Van Dorn Mechanical Hoists are built in light and heavy duty capacities in models to fit every type of power-drive or design of chassis. They are recommended by all leading dump truck manufacturers and can be installed by any truck dealer or service station. Hoists and all necessary drive parts are designed to conform to adopted standard automotive practice and can be very easily serviced by any automobile mechanic.

CATALOGUE

For complete data on Van Dorn Truck Hoists and Bodies send for catalogue and price lists.

THE SWINTEK TRAVELING SUCTION SCREEN NOZZLE CO.

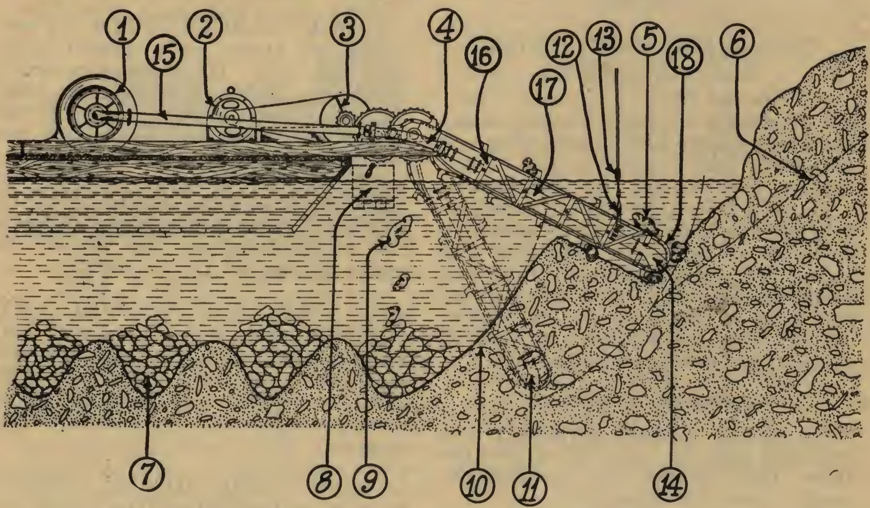
MAIN OFFICE AND FACTORY: EDDYVILLE, IOWA

PRODUCTS

Swintek Traveling Screen Nozzle

Gravel Beds, especially in river bottoms, have a habit of developing unexpected boulders, tree trunks, limbs, waterlogged posts, etc.

The Swintek Traveling Suction Screen Nozzle fully meets this problem. The jaws of the cutter tear up and loosen the gravel, hardpan, etc., while the traveling belt carries away all boulders; also debris that would otherwise obstruct the suction nozzle. It is adjustable and as it eats its way into the gravel bar, it describes an arc that swings from the surface to the lowest point the nozzle will reach. With the Swintek Traveling Suction Screen Nozzle hard and solid deposits can be worked as easily as any other.



EXPLANATION OF DIAGRAM

No. 1—Centrifugal pump driven by engine or motor.

No. 2—Motor that drives the Traveling Screen.

No. 3—Safety Friction Clutch that automatically stops traveling screen should the jaws encounter obstacles so big or so solid as to threaten breakage to the equipment.

No. 4—Flexible Hose Coupling—an important feature of the Swintek Traveling Suction Screen Nozzle—allows nozzle to be easily raised and lowered without interfering with the flow of gravel through pipe.

No. 5—Boulder being carried from in front of suction by the traveling chain.

No. 6—Angle of subsidence to which bank naturally slides down when nozzle is working in position shown.

No. 7—How machine deposits rocks out of the way, behind the bank face being worked.

No. 8—Small pontoon boat that may be used to catch boulders brought up by traveling belt, if it is desired to save these boulders.

No. 9—Boulder being dropped to a pocket at bottom, many others being shown in these pockets made by nozzle in each successive pumping position.

No. 10—Ridge left between pockets on bottom, prevents boulders rolling forward under suction nozzle the second time.

No. 11—Lowest point of suction nozzle in working position.

No. 12—Bail to which is attached cable for raising or lowering suction nozzle. (Frame supported on pontoons is shown in catalogue.)

No. 13—Pulley blocks for cable for raising or lowering nozzle.

No. 14—Intake of nozzle.

No. 15—Pipe lead from C Pump to connect with flexible hose which allows machine to be raised or lowered.

No. 16—Bracket made of cast steel bolted to the pipe, and riveted to heavy angles which make very rigid construction.

No. 17—Pipe in center of agitator frame which makes part of construction of frame.

No. 18—Arcuate track, consists of heavy steel casting and is so arranged with manganese liners and side rollers so the wearing parts can be easily replaced without replacing large casting.

AMERICAN MANGANESE STEEL CO.

GENERAL SALES OFFICES, 387 E. 14TH ST., CHICAGO HEIGHTS, ILL.
PLANTS: CHICAGO HEIGHTS, ILL. NEW CASTLE, DEL. OAKLAND, CALIF.

AMSCO

PRODUCTS

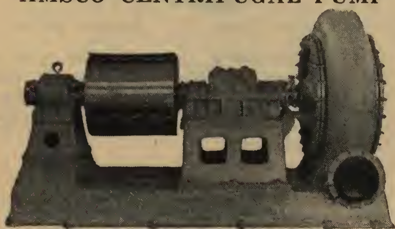
AMSCO manganese steel pumps, pump shells, liners, impellers and discs.

Ask for our Pump catalogue.

AMSCO manganese steel dippers, etc., are catalogued on page 231.

AMSCO manganese steel chain is catalogued on page 211.

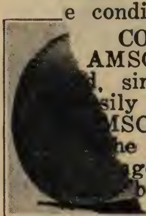
AMSCO CENTRIFUGAL PUMP



Wherever there is sufficient water at hand or wherever water may be conducted to the operation the centrifugal sand and gravel pump provides a very economical and efficient means of excavating materials. This pump is employed with distinct advantages in many operations—at pit excavation or bank excavation work and at hydraulic mining. It excavates, conveys, elevates and washes the material handled in one operation.

This material being of abrasive :haracter, reduces the life of the ump shells, impellers and other conıct parts of the pump, thus creating demand for a metal capable of withanding this severe wear.

foManganese steel possesses greater quistance to abrasive wear than any ɜr known metal. AMSCO pumps le of AMSCO manganese steel given efficient and economic ce for many years under the most e conditions.



CONSTRUCTION

AMSCO pump is rigidly cond, simple in design with all sily accessible.

MSCO pump shell has no stud he two side plates have ges in the shell. Into these bolts are dropped. This prevents stud bolts being broken or worn off by abrasion and permits the use of solid ring gaskets.

The suction side plate projects into the opening of the impeller. No sand or gravel can drop between impeller and side plate. The opening between impeller vanes is large, permitting all solids to enter and pass through freely. The hub of impeller does not project inside of the impeller and offers no resistance to the flow of materials.

The shaft of the AMSCO pump is unusually large in diameter and is supported by a large bearing close to the pump, reducing over-hang of the shaft to a minimum, eliminating vibration, springing and breaking of the shaft.

End thrust is taken care of by thrust collars in the main bearing and a ball bearing thrust collar. On all heavy duty belted pumps, and direct connected units a Marine Type bearing is used. By reversing the side plates the pump can be changed from a left hand to a right hand pump or vice versa—with the substitution of a right or left hand runner, as the case may demand.

AMSCO pumps are furnished in 4-, 6-, 8-, 10-, 12-, 15-inch and larger sizes.

PUMP PARTS

We also supply AMSCO manganese steel shells, liners, runners and discs for all makes of standard steel lined pumps.

ENGINEERING SERVICE

We maintain a corps of engineers that are at your service in assisting you in solving your excavating problems. You are placed under no obligation in consulting with them.

ERIE PUMP & ENGINE WORKS

150 GLENWOOD AVE., MEDINA, N. Y.

PRODUCTS

Sand-Gravel Dredging Pumps
Water Supply Pumps
Quarry Drainage Pumps
High Pressure Jetting Pumps
Mine Pumps, Fire Pumps
Centrifugal Pumps

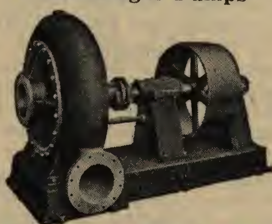


Fig. 227—Dredge Pumps, Belt Drive.

DREDGE PUMPS:

Standard and high duty types for hardest service. 4″ to 15″ sizes inclusive. Larger sizes will deliver through upwards of one mile of pipe line.

Built for belt drive and direct connection to electric motor, steam, gasoline or oil engines.

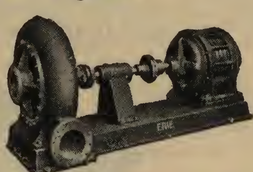


Fig. 322—Dredge Pump, Motor Drive.

The durability and economy of "Erie" equipment are the result of over 30 years' experience in building dredging pumps.

Write for Bulletin 35.

Complete lines of dredge pump fittings and accessories furnished.

WATER PUMPS:

We manufacture five complete lines of water pumps, adapted for all standard methods of drive, thus enabling us to meet every pumping requirement of pit and quarry.

Fig. 239—Class "L," Engine Drive.

Low pressures up to 20 lbs. per sq. inch. Low speeds and simple construction adapt these pumps for contractor's work, quarry and shallow mine drainage.

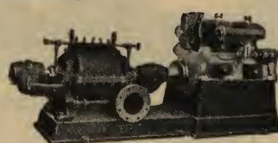


Fig. 235—Type "MS," Gasoline Drive.

Pressures up to 200 lbs. per sq. inch for jetting, fire-pump or deep-mine drainage.

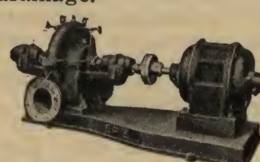


Fig. 257—Type "S," Motor Drive.

Moderate pressure up to 100 lbs. per sq. inch for general clear water supply.

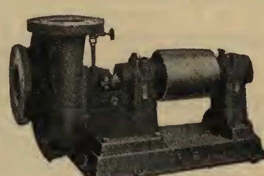
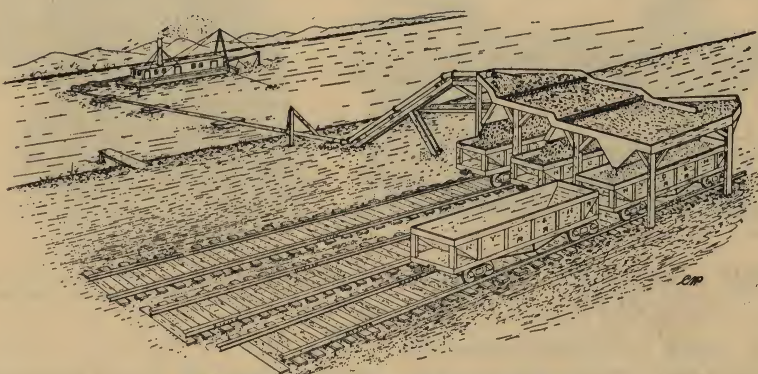


Fig. 263—Type "O," Belt Drive.

Low and moderate pressure up to 50 lbs. per sq. inch. Will handle muddy water, leaves, trash, etc. Rugged and compact for general utility pumping.

MORRIS MACHINE WORKS

BALDWINSVILLE, N. Y.



Typical Sand and Gravel Pumping Plant

PRODUCTS

Morris Centrifugal Pumps, Hydraulic Dredging Machinery, and Steam Engines, up to 1,000 H. P. Write for our complete catalog.

Sand and Gravel Producers:

In selecting equipment for your plant, please bear the following in mind:

1. The dredging pump is the most efficient digging machine.

2. The dredging pump is the most efficient scrubbing and washing machine.

3. The dredging pump is the most efficient conveying and elevating machine.

In installing our hydraulic dredging plant you will secure the benefit of all three and your material will be excavated, washed, and delivered where you want it at one operation at one-third the cost.

The illustration above shows a typical plant of this kind. The dredging pump on the barge picks up and delivers the material through the pipe to the screening plant. The grains of material are washed thoroughly while traveling through the pump and pipe and the impurities are carried off with waste water.

Our engineering department with over 59 years of experience behind it is at your service in helping you to solve your problem.

Write us today, giving full description of your material, the capacity desired, the depth of water in which it is proposed to pump, the required length of discharge line, the required lift above the water surface, the

MORRIS MACHINE WORKS

method of drive, and the kind of power to be used. If electric power is to be used, give current characteristics.

We build dredging pumps for all purposes and can furnish you the pump suited exactly for your material, capacity, and head. A short description of the types most commonly furnished is given on the next two pages.

Fig. 54—Morris standard dredging pump direct connected to steam engine.

MORRIS STANDARD DREDGING PUMP

This pump is recommended for moderate duty. Built in sizes 4 in. to 15 in., and can be furnished both lined and unlined.

Fig. 19—Morris standard belt driven dredging pump.

Morris standard dredging pumps have shell cast in one piece, very heavy, with extra metal provided in such parts subject to greatest wear.

These pumps are furnished either with belt drive or directly connected to engine.

MORRIS HEAVY DUTY DREDGING PUMP

The Morris Heavy Duty Dredging Pump is recommended for heavy duty and wear. Built in sizes 3 in. to 24 in. inclusive. Can be furnished lined or unlined with wearing parts of hard semi-steel, carbon steel or manganese steel. This is the pump most commonly used in sand and gravel pumping plants as it meets pumping plant requirements with greatest efficiency.

Fig. 220—Morris Heavy duty belt driven Dredging Pump.

MORRIS MACHINE WORKS

Fig. 221—Morris Heavy duty dredging pump. Dir. con. to elec. motor.

SOLID LINED PUMPS

Morris solid lined dredging pump, lined throughout with hard cast iron or manganese steel lining. Built in sizes 2 in. to 12 in. inclusive, both for belt drive or direct connection. A very high grade pump recommended especially for handling sharp sand.

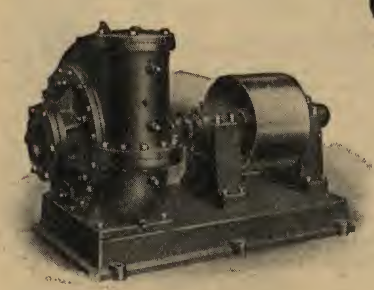


Fig. 108—Morris solid lined belt driven dredging pump.

In addition to the pumps described here, we have many designs of special types and combinations which we have furnished in the past and which may be just right for your requirements.

HORIZONTALLY SPLIT DOUBLE SUCTION PUMP

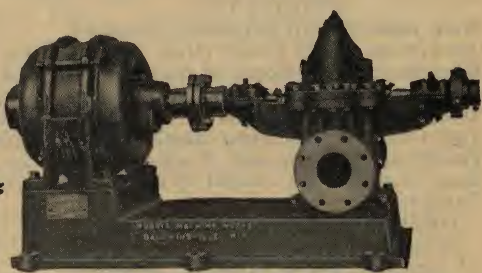


Fig. 201—Morris H. S. D. S. Pump.

This type is adapted for high efficiency and direct connection to motor. Used for furnishing water to jet heads, stuffing boxes, priming, etc.

HORIZONTALLY SPLIT MULTI-STAGE PUMPS

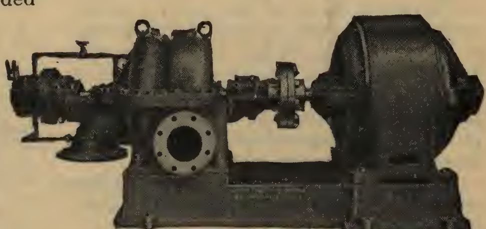


Fig. 200—Morris H. S. M. S. Pump.

Recommended for supplying water at high pressure. A splendid pump for hydraulicking.

PUMP PARTS

We also furnish cutters, suction heads, pipe fittings, pipe, suction hose, jet heads, pontoon sleeves, and other auxiliaries required on dredging installations.

Branches in principal cities

Established 1864

A. LESCHEN & SONS ROPE CO.

5909 KENNERLY AVE., ST. LOUIS, U. S. A.

NEW YORK CHICAGO DENVER SAN FRANCISCO

PRODUCTS

Wire Rope for all purposes, including the famous HERCULES (Red-Strand) Wire Rope, Wire Ropes of both Round and Patent Flattened Strand construction, Locked Wire Ropes and Locked Coil Cables; Wire Rope Blocks, Clips, Thimbles, Sockets and Hooks; Wire Rope Lubricants; Aerial Wire Rope Tramways.

DESIGN AND WORKMANSHIP

Every process in the manufacture of Leschen Wire Rope is according to our own exclusive methods and is accompanied by exacting tests and rigid inspections. Each rope is made to conform to the design that we have found from experience to be best for the particular work the rope is to perform.

KINDS OF MATERIAL

Leschen Wire Ropes for pit and quarry use are generally furnished in the following grades:

"Hercules" Wire Rope

Reg. U. S. Pat. Off.

This is a rope of the very highest quality. It is the correct combination of strength, elasticity, toughness and flexibility for maximum service. It is the best that can be bought at any price, and because of its durability it is the most economical rope for heavy work than can be obtained.

HERCULES Wire Rope always has one red strand for identification purposes.

"Special Steel"

Reg. U. S. Pat. Off.

A rope of but moderate cost but it possesses high efficiency in a wide variety of operating conditions. Its flexibility is equal to that of lower strength ropes, and its trustworthiness within its working limit is exceptional.

Cast Steel

Cast Steel Rope is standard for ordinary work, being of moderately high tensile strength and quite flexible.

Plow Steel

Plow Steel Rope is of high tensile strength and one that is used successfully for heavy work where sufficiently large drums and sheaves are practicable.

CONSTRUCTIONS

Fig. 1. This is the standard Round Strand hoisting construction. Its use is quite general on cranes, cableways, derricks, dredges, excavators, grab buckets, steam shovels, etc.

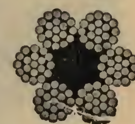


Fig. 1

Fig. 2. An extra flexible Round Strand construction for use where sheaves and drums are necessarily small. Especially recommended for cranes.

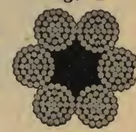


Fig. 2

Fig. 3. A Patent Flattened Strand construction, and an ideal rope for conditions requiring unusual strength and resistance to wear. Highly recommended for heavy duty cranes, cableways, excavators, steam shovels, etc.

Fig. 3

Fig. 4. Standard Round Strand haulage rope for inclines, and is also used as track and traction rope on Aerial Tramways.

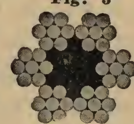


Fig. 4

Fig. 5. Patent Flattened Strand haulage rope. This is a heavy duty rope for haulage purposes, because of its exceptional ability to withstand surface wear. It is also used for track rope on Aerial Tramways.

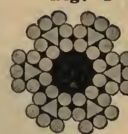


Fig. 5

Fig. 6. This Patent Flattened Strand construction of haulage rope is an ideal traction cable on Aerial Tramways. It is used with remarkable success for this class of service.

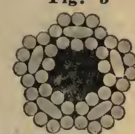


Fig. 6

Fig. 7. Locked Wire Rope is an ideal rope for main line on cableways. Its smooth surface minimizes wear and friction, and reduces vibration.

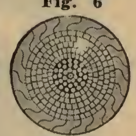


Fig. 7

Fig. 8. Locked Coil Cable is designed and recommended for track rope on Aerial Tramways. It offers the same advantage for this service as Locked Wire Rope for cableways.

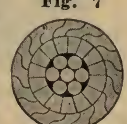


Fig. 8

A. LESCHEN & SONS ROPE CO.

Wire Rope Data Tables Showing Weights, Approximate Breaking Strengths, Usual Working Loads and List Prices. (Tons of 2,000 pounds.)

Leschen Standard Round Strand Hoisting Ropes (6x19) Figure 1

Diameter in inches	Weight per foot in pounds	"Hercules" (Red-Strand) Rope		"Special Steel"		Cast Steel		Plow Steel	
		Approx. Breaking Strength in tons	List price per foot	Approx. Breaking Strength in tons	List price per foot	Approx. Breaking Strength in tons	List price per foot	Approx. Breaking Strength in tons	List price per foot
¼	.10	3.15	$0.13	2.43	$0.10½	2.2	$0.09	2.65	$0.12
5/16	.15	4.50	.13½	3.50	.10¾	3.1	.09¼	3.8	.12¼
⅜	.22	6.75	.14½	5.30	.11	4.8	.09½	5.75	.12½
7/16	.30	9.4	.15½	7.25	.11½	6.5	.10	8.	.13
½	.39	12.1	.17	9.2	.12½	8.4	.11	10.	.14
9/16	.50	14.5	.19	11.2	.14	10.	.12	12.3	.16
⅝	.62	19.	.22½	14.	.16½	12.5	.14	15.5	.19
¾	.89	26.3	.31	20.2	.22	17.5	.19	23.	.26
⅞	1.20	35.	.39	26.	.29	23.	.24	29.	.34
1	1.58	45.	.50	34.	.37	30.	.31	38.	.43
1⅛	2.	56.	.62	43.	.46	38.	.38	47.	.54
1¼	2.45	69.	.75	53.	.56	47.	.46	58.	.65
1⅜	3.	84.	.90	64.	.68	56.	.56	72.	.79
1½	3.55	98.	1.10	73.	.80	64.	.66	82.	.93
1⅝	4.15	110.	1.30	83.	.94	72.	.77	94.	1.08
1¾	4.85	133.	1.60	99.	1.10	85.	.90	112.	1.30
1⅞	5.55	150.	1.75	112.	1.25	96.	1.02	127.	1.46
2	6.30	166.	1.85	123.	1.34	106.	1.16	140.	1.58
2¼	8.	210.	2.50	160.	1.70	133.	1.44	186.	2.00
2½	9.85	263.	2.80	200.	2.10	170.	1.75	229.	2.50

Leschen Patent Flattened Strand Hoisting Ropes (6x25) Figure 3

Diameter in inches	Weight per foot in pounds	"Hercules" (Red-Strand) Rope		"Special Steel"		Cast Steel		Plow Steel
		Approx. Breaking Strength in tons	List price per foot	Approx. Breaking Strength in tons	List price per foot	Approx. Breaking Strength in tons	List price per foot	
⅜	.25	7.4	$0.18¼	5.8	$0.15¼	5.3	$0.12½	Not furnished in Patent Flattened Strand Construction.
½	.45	13.3	.20¾	10.1	.17½	9.3	.14½	
9/16	.58	16.	.25	12.3	.19½	11.	.16½	
⅝	.72	21.	.28	15.4	.22½	13.8	.18¼	
¾	1.	29.	.37½	22.2	.30	19.3	.24	
⅞	1.38	39.	.49	29.	.38	25.	.30	
1	1.80	50.	.60	37.	.48	33.	.39½	
1⅛	2.30	62.	.71	47.	.59	42.	.50	
1¼	2.80	76.	.89	58.	.70	52.	.59½	
1⅜	3.45	92.	1.12	70.	.90	62.	.73	
1½	4.	108.	1.37	80.	1.05	70.	.86	
1⅝	4.75	121.	1.56	91.	1.30	79.	.96	
1¾	5.60	146.	2.08	109.	1.55	94.	1.21	
2	7.25	183.	2.25	135.	1.77	117.	1.44	
2¼	9.20	231.	2.85	176.	2.20	146.	1.82	
2½	11.2	289.	3.50	220.	2.80	187.	2.20	

The usual safe working load for a wire rope is from one-fifth to one-seventh of its breaking strength, depending upon the nature of the work.

The data here given covers the types of ropes most generally used for pit and quarry purposes. We will be glad to furnish our catalog giving complete data on all wire ropes of our manufacture.

Tell us the working conditions of your wire rope, and we will suggest the proper rope for the most economical results.

L. P. GREEN

905 LUMBER EXCHANGE BLDG., CHICAGO, ILL.

POWER DRAG SCRAPERS

GREEN BOTTOMLESS SCRAPER

are built strong enough to stand the most severe strains and yet weigh only about 20% of the handling capacity.

All wearing parts are replaceable so as to make the life of scraper practically indefinite. Sizes range from 1/3 to 5 cu. yds. and larger can be furnished if desired.

Operated by any standard two drum hoist, using either steam, electric, gasoline or oil for power. Also a valuable assistant to a crane for handling material that cannot be reached with boom.

Will handle material cheaply from under water or from dry deposits, but for hillside deposit scraper positively has no equal.

The installation is simple and requires no expensive overhead equipment, though an inexpensive overhead arrangement can be made to return Scraper by gravity, if conditions justify.

The operating radius is an average of about 300 ft. but can be extended if necessary; and one man with Power Scraper Outfit handles the entire operation from the Pit to the Plant or Loading Bins.

We can furnish complete Outfits as small as 1/3 Cubic Yard, with Belt Hoist, as low as $714.00; or, Outfits as large as 5 Cubic Yard Scraper with 200 H.P. Electric Special Scraper Hoist, for approximately $8800.00. Note that this large Outfit costs very little more than the smallest power shovel or crane.

Will sell Scraper only, or Complete Plant, as desired.

We have made over 200 installations in the past three years and can show all sizes of scraper in successful operation, doing almost every conceivable kind of work, such as delivering sand and gravel-brick clay to belt conveyor and bucket elevators—or directly into bins for wagon or truck loading—storage handling—stripping gravel pits, clay pits, quarries and coal deposits and various sorts of grading and excavating.

We have compiled considerable information, photographs, drawings, etc., and have now organized so as to give better service than ever before. We can give assistance and advice, both from our own experience and the experience of others, that would cost you considerable to obtain if you have not already had this experience.

Don't waste time and money experimenting. Write us in detail about your particular problem. An exchange of information costs you nothing and may save you considerable money.

PAGE ENGINEERING COMPANY

189 W. MADISON ST., CHICAGO, ILL.

PRODUCTS

Page Scraper Buckets (Patented), Complete Dragline Machines for Operating Page Scraper Buckets, Using Steam or Oil Engine Power and Having Booms From 50 to 125 Feet in Length

Page bucket is adaptable to use either in bank or bed material, or equipment designed to perform the functions of a shovel, conveyor and elevator combined.

THE PAGE PATENTED SCRAPER BUCKET

is standard equipment on all makes of dragline machines. Moreover the

Page Scraper Buckets are furnished in four classes from the Class M, light type, to the Class H, extra heavy type and are made in sizes from ½ to 6 cubic yard capacity.

SAUERMAN BROS.

426 S. Clinton St., CHICAGO, ILL.

Agents in 25 principal cities

PRODUCTS

Sauerman Power Drag Scrapers and Portable Scraper Outfits
(Write for Pamphlet No. 18)
Cableway Excavators **(See Page 235)**

Sauerman "LeClair" Scraper Digging Hard-Packed Gravel and Delivering to Crusher at Screening Plant

POWER DRAG SCRAPERS

Uses—In excavating bank deposits of gravel, stripping overburden, storing and reclaiming crushed stone, gravel or coal, Sauerman power drag scrapers are money-savers because they possess large capacity, yet require no great outlay to install, operate and maintain. They show greatest economy in handling materials distances of 200 to 400 ft.

Description—There are three distinct types of Sauerman power scrapers, "Excavator," "LeClair" and "Crescent," each best suited to a particular class of work. All are bottomless, hence self-loading and self-dumping. The operation consists simply of dragging the scraper back and forth over the deposit or pile that is to be excavated or rehandled. When the scraper reaches the dumping point, the operator causes it to deposit its load automatically by putting the pull-back cable in operation.

All Sauerman scrapers are simple and rugged and wearing parts are renewable. With slight maintenance expense these scrapers may last indefinitely.

Sizes—Standard sizes of Sauerman Power Scrapers are from 1/3 to 5 cu. yd. Larger sizes can be built to order as specified.

A portable power scraper outfit, designed for light excavating and material-handling is offered in two sizes, ¼ and ½ cu. yd., with operating spans of 200 ft.

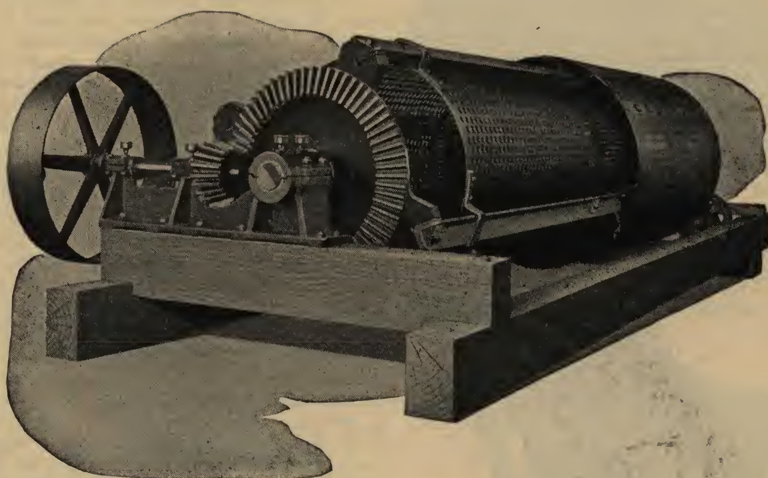
Service—If the illustrations here and on page 235 do not give you sufficient evidence of the adaptability of Sauerman equipment for your conditions and requirements, submit your problem to Sauerman engineers. Their experience, gained through contact with over 1,000 installations of Sauerman cableways and power scrapers, is freely at your service.

Tell us what you want to accomplish, daily yardage you require and the surrounding conditions and we will suggest the type of equipment and general layout that will give you the desired result at lowest cost.

Sauerman "Crescent" Scraper Storing and Reclaiming Crushed Stone

W. TOEPFER & SONS CO.

MILWAUKEE, WIS.



PRODUCTS

- Revolving Screens
- Screening Machinery
- Elevators
- Sand Washers
- Grizzlies.
- Feeders
- Conveyors
- Bin Gates
- Perforated Metals

TOEPFER HEAVY DUTY SCREEN

This screen is built extra heavy, of the best material, to stand the most severe strain and wear. The head ring at the receiving end is made of cast steel; the rollers are of large diameter cast with chilled face and are mounted on large shafts with generously large bearings; all other castings used in the construction of this screen are cast of semi-steel; the angle frame holding the screen sections in place are large and of heavy section; the main bearings at drive end are extremely heavy and cast in one unit; the timber frame is made of select dressed pine; the screen sections are made of steel plates of high carbon content to stand unusual wear, and are so set in screen that they can be replaced readily and with little trouble

Screens can be furnished with or without Sand-Jacket as desired; drive pulley can be furnished for right or left hand drive.

UNIVERSAL VIBRATING SCREEN COMPANY

1528 Owen Ave., RACINE, WIS.

PRODUCTS

Universal Vibrating Screens.

THE UNIVERSAL VIBRATING SCREEN

The effectiveness of the vibratory motion in screening crushed stone, gravel or other mineral aggregate has become universally recognized. And in the Universal Vibrating Screen the vibratory motion reaches its highest efficiency.

If your requirements are such that your material must be of uniform sizes, this screen will fulfill your requirements in an efficient manner.

They have an exceptionally large capacity due to the intensive vibratory motion, which is exactly the same at any point on screen cloth.

A change from a cloth of one mesh to that of another mesh can be made in 15 minutes by removing tension bolts and slipping out cloth which is attached to angles, from either end of screen frame. The second cloth is then slipped into place and tension bolts drawn up with wrenches provided for that purpose. A tension should be kept on screen cloth, and this can be adjusted within a few seconds, even while machine is in operation.

Screen cloth used is 3 feet wide and 8 feet long, and is a stock width carried by any manufacturer of screen cloth. This eliminates all chance of delay thru having to send for special sizes of cloth, and stock widths are furnished at a lower price.

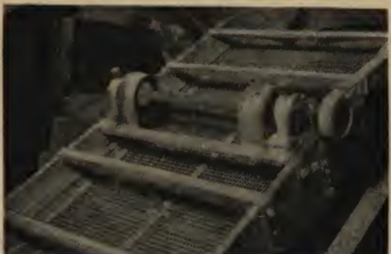
These screens are operated on the gravitation principle, therefore the large saving in power. As material passes over screen, 1,800 vibrations per minute forces screen cloth into material, agitating it and removing everything that will go through the mesh of screen used.

Only a ¾ H. P. motor is required to operate one of these screens, making the power cost less than three cents per hour.

CONSTRUCTION

The Universal Vibrating Screen was designed and built by several of the leading engineers in the crushed stone and gravel industries. In construction it is simple and extremely strong, being built throughout of steel, maple and oak. There are no cams, ratchets, knockers or other frictional surfaces to give trouble.

The upper frame is supported from the lower frame by means of springs. This keeps the vibration entirely in the upper frame. The vibration is developed in the counter shaft, by means of its off center weights, which travel at 1800 R. P. M. Specially designed dust proof housings are used for the S. K. F. Self Aligning Ball Bearings. These bearings are guaranteed by the S. K. F. Industries, as used in our installation. The only attention required is a little clean grease every few weeks.



Screens are furnished with or without motors. Complete description and price on application.

WELLER MANUFACTURING CO.

1820-1856 N. Kostner Ave., CHICAGO

PRODUCTS

We Make a Complete Line of Screens Adapted to the Handling of Sand, Gravel and Crushed Stone and List on This Page only a Few of the Types We Are Making.

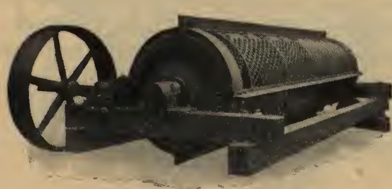
Catalogue 35H gives description also data that will help in making your selection.

Sent on request.

Weller Elevating and Conveying Equipment is Catalogued on Page 254 of This Book

FULL TRUNION SUPPORTED SCREEN
No center shaft, driven through trunion shaft.

WELLER MADE CHICAGO

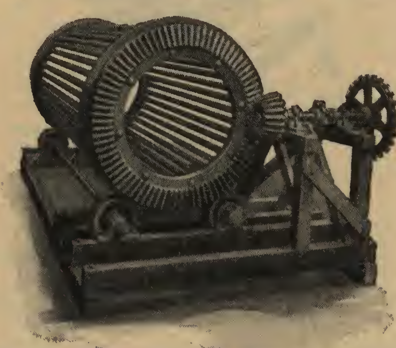


EXTRA HEAVY STONE SCREEN

Semi-trunion supported, furnished with or without dust jacket or housing.

RECIPROCATING SCREEN

Supported by rollers on track, with grizzly bottom to remove fines.



DOUBLE TRUNION PIPE SCREEN

Illustration shows bevel gear drive.

DOUBLEDECK RECIPROCATING SCREEN

Supported by pivot brackets, perforated metal bottom plates.

When in the Market for Elevating Conveying and Power-Transmitting Machinery Write Us

MARION STEAM SHOVEL COMPANY

MARION, OHIO

DISTRICT SALES OFFICES—NEW YORK CHICAGO ATLANTA

Representatives listed on opposite page

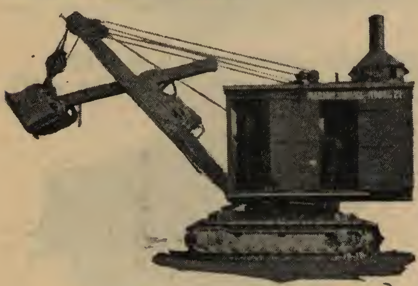
PRODUCTS

Steam, Gasoline and Electric Shovels in revolving and railroad types ranging in size from ¾ to 8 cu. yds. dipper capacity.

Dragline, clamshell and orangepeel excavators with booms ranging in length from 35 to 150 feet.
Dipper, clamshell and hydraulic dredges. Placer elevator dredges.

SMALL REVOLVING SHOVELS, DRAGLINE, CLAMSHELL AND ORANGEPEEL EXCAVATORS

Three sizes with Steam, Gasoline or Electric Power mounted on Crawling Traction, Railroad wheels or wide faced traction wheels.



Model 21—17½, 20 or 22 ft. boom, ¾ or 5/8 yd. dipper. Rated capacity 30-60 cu. yds. per hour.

Model 32—21, 24 or 27 ft. boom, 1¼ or 1 yd. dipper. Rated capacity 50-100 cu. yds. per hour.

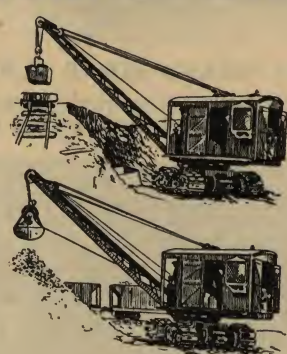
Model 37—25, 28½ or 32 ft. boom, 1¾ or 1¼ yd. dipper. Rated capacity 70-140 cu. yds. per hour.

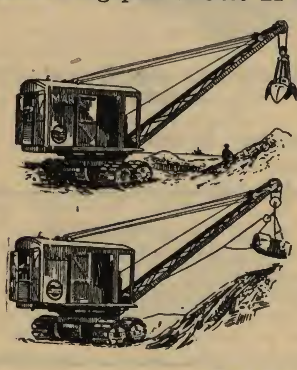
High Lift Equipment is supplied where extra reach or height dump is required. Shovel and crane attachments are interchangeable on the same machine, thus adapting each model to a large variety of work.

WITH CRANE ATTACHMENTS AND WITH CRAWLING TRACTION

Model 21 carries a 35-ft. boom. It has a lifting capacity of 6,500 lbs. at a 35-ft. radius and can be equipped with ¾ cu. yd. dragline or clamshell bucket or 15 cu. ft. orangepeel bucket.

Model 32 crane boom is 40 ft. long and has a lifting capacity of 10,000 lbs. at a 40-ft. radius. Dragline or clamshell bucket has a capacity of 1 cu. yd.—orangepeel bucket 21 cu. ft.





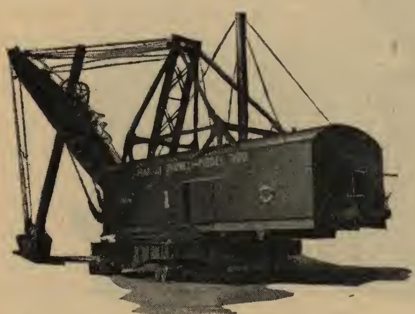
Model 37 carries a 50-ft. boom and has a lifting capacity of 11,500 lbs. at a 50-ft. radius. It can be equipped with 1½ cu. yd. dragline or clamshell bucket or 1¼ cu. yd. orangepeel bucket.

MARION STEAM SHOVEL COMPANY

RAILROAD TYPE SHOVELS

Built in seven sizes—from ¾ to 6 cu. yd. dipper capacity. They can be furnished with railroad trucks or with wide faced traction wheels. With the exception of Model 41 all shovels of this type can be furnished with crawling traction trucks—a mounting admirably suited to quarry or pit. Models 51, 61, 70 and 92 can be furnished with electric power.

LARGE REVOLVING SHOVELS AND DRAGLINES



Where deep overburden is encountered or extreme maximum reach and height dump are required, we recommend shovels of this type. Their wide working range in the handling of overburden, stone or gravel causes less frequent shifting of the working and loading tracks which greatly increases the output and materially reduces the digging and loading costs.

Shovel and dragline attachments are interchangeable on the same machine. Models 282 and 300 can be furnished with steam or electric power—other models in this type with steam only.

IF INTERESTED, GET IN TOUCH WITH OUR NEAREST REPRESENTATIVE

Atlanta, Ga.—Candler Bldg., C. W. Fries.

Billings, Mont.—Connelly Machinery Co.

Chicago, Ill.—1442 Monadnock Block, R. H. Rossiter.

Dallas, Texas—1125 Busch Bldg., Fred B. Wright.

Denver, Colo.—18th & Wazee Sts., H. W. Moore & Co.

Detroit, Mich.—Brush & Macomb Sts., W. H. Anderson Tool & Supply Co.

Ft. Smith, Ark.—Goldman Hotel, Wm. Rinehart.

Grand Rapids, Mich.—303 Bridge St., W. H. Anderson Tool & Supply Co.

Montreal, Quebec—F. H. Hopkins & Co., Limited.

New Orleans, La.—518 Conti St., C. H. Stem.

New York—50 Church St., Roy Jacoby.

Philadelphia, Pa.—1201 Colonial Trust Bldg., H. L. Cox.

Pittsburgh, Pa.—324 4th Ave., John W. Patterson.

Portland, Ore.—18th & Upshur Sts., Clyde Equipment Co.

Salt Lake City, Utah—141-143 Pierpont Ave., H. W. Moore & Co.

San Francisco, Calif.—Monadnock Bldg., Ricker Machinery Co.

Seattle, Wash.—542 First Ave., South, Clyde Equipment Co.

Spokane, Wash.—E. 131 Main St., Clyde Equipment Co.

St. Louis, Mo.—Branscome Hotel, C. B. Watrous.

Toronto, Ontario—F. H. Hopkins & Co., Limited.

Vancouver, B. C.—1155 Sixth Ave., West, Vancouver Machinery Depot, Limited.

NORTHWEST ENGINEERING COMPANY

1236 STEGER BLDG., CHICAGO, ILL.

Agencies in forty principal cities

PRODUCTS

The Northwest Gas Shovel
The Northwest Electric Shovel
The Northwest Crane
The Northwest Dragline

The Northwest shovel cleaning up a quarry floor.

THE NORTHWEST SHOVEL

The Northwest Gas or Electric Shovel eliminates the short-comings of former shovel construction—the lack of crowding power; the failure to withstand the ceaseless shocks of handling heavy stone; the inability to maneuver in close quarters—these are the faults that have been corrected in the Northwest Crawler Shovel.

The Northwest has but one motor; gas or electric as desired. And every function — hoisting, swinging, or thrusting in or out—has the full power of this one motor behind it. That is why the Northwest gives 15% to 25% more power at the dipper lip—why it is known for greater crowding power.

The different movements are imparted to the dipper stick by means of cables. Thus gears, racks, sprockets, chains, and auxiliary driving engines or motors are eliminated, and at the same time the high maintenance cost of these short lived complications is avoided. There is practically nothing to wear out.

The Northwest digs as it hoists, imparting a breaking, prying action to material. All other shovels impart a horizontal crowding operation to the dipper, followed by a hoisting action. The two operations are separate. In the Northwest, one operation takes the place of the two operations of other shovels.

NOTE THESE FEATURES

1. Short lived gears, racks, and crowding engines, motors, or auxiliary drivers for the dipper stick, have been replaced by an ingenious arrangement

NORTHWEST ENGINEERING COMPANY

of cables which carry out every function—thrusting in or out, hoisting, and shaking the dipper. Thus the full power of the engine is always available at the dipper lip, providing a greater crowding force than is possible with any other construction. There is nothing to wear out but the cables! And with this arrangement even the cables give unusually long life.

2. Because of this simple rig, only one motor is needed—a 57 h. p. heavy-duty gas engine—which provides power far in excess of heaviest requirements, or an electric motor of equivalent capacity.

3. The shovel mechanism is mounted on the famous Northwest crawler—the crawler that steers like a truck. Instead of the usual method of stopping one side of the crawler when turning or manoeuvering, one side is driven slower, which insures positive traction so essential in the rough going encountered in quarry work

4. The dipper has reversible manganese teeth and is full ¾ yard struck measure. The shovel has great back reach and will dig 30 feet flat width four feet below grade.

The Northwest crane loading storage bin.

The Northwest Dragline

THE NORTHWEST CRAWLER CRANE AND DRAGLINE

Of this time tested machine users have said that it is the most useful, the most versatile device that is available for quarries and for sand and gravel pits. By means of its patented steering device controlling the rugged powerful crawler base, it moves from job to job over rocks, uneven surfaces or any kind of obstructions. It handles a one yard clamshell or dragline bucket at a speed that gives it greater capacity than much heavier machines. It is the work of only a few hours to interchange the buckets.

Use the Northwest for stripping, loading, stocking bins, piling up stock, double decking materials—and watch your operating costs drop. One man steers the crawler, controls the engine, and operates the bucket.

BULLETINS

Illustrated bulletins, containing complete specifications, describe all Northwest equipment. Every quarry operator should have file copies.

THE ACME ENGINEERING COMPANY

201 Beckel Bldg., DAYTON, OHIO

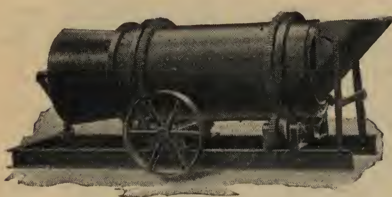
PRODUCTS

Acme Washers for sand, gravel and stone.

Ask for our catalogue

THE ACME WASHER

The Acme Washer for sand, gravel and stone is so constructed that both washing and screening are combined in one unit. This combining of two operations conserves space, time and money.



CONSTRUCTION

The Acme Washer is built with a steel cylinder revolving on four positively driven rollers. At each end is a special casting designed to maintain a depth of water of approximately four inches in the bottom of the inside. Attached to the inner surface of the cylinder is a series of metal buckets.

Sand and gravel or stone enters from the hopper located at the intake end, falling directly into the water. As the cylinder turns, each bucket cuts out a definite amount, carrying it upward until it arrives at a position which causes the material to slide out and back into the water in the next space forward. This operation is repeated through each set of buckets, the last set delivering the washed material to the screens attached to the discharge end.

During its progress through the cylinder, the material is constantly in motion, the peculiar form of bucket giving it a twisting motion which tends to rub free any extraneous matter soluble in water. A water spray on the axis of the screens clears the perforations of sand.

The design of the buckets is such that there are no stationary parts to catch oversize material and become loosened. Any stone small enough to enter the buckets will pass through without damage to the equipment.

The machine is supported on a steel frame of channel construction, and may be fitted with one, two or three conical screens, of any suitable mesh, at your option.

The drive is through bevel gears directly to the rollers and gear rings. The speed of the drive shaft is readily adjustable to the speed of the head shaft on a bucket elevator.

Number 30 washer, because of its lightness, is readily portable and can quickly be installed anywhere convenient to an adequate supply of water.

Size of Washer	No. 30	No. 40
Tons per hr.	15	50
Water per min. gal...	30	100
Power (H. P.)	3	10
Length	9′ 10″	17′ 6″
Height	4′ 1″	6′ 1″
Speed of dr. shaft-R. P. M.	65	85
No. of sizes of product	4	4

Acme Washers as regularly built discharge the water from the end at which the material enters. In this case no separating tanks are necessary. We can, however, supply these washers to discharge the water with the material.

THE CLEVELAND WIRE CLOTH & MFG. CO.

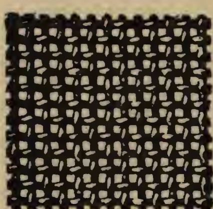
3579 East 78th Street, CLEVELAND, OHIO

PRODUCTS

Double Crimped Wire Cloth

"CLEVELAND" DOUBLE CRIMPED WIRE CLOTH

Years of experiment and experience have given to the Cleveland Wire Cloth and Manufacturing Company products an unqualified superiority over all other grades of wire cloth.



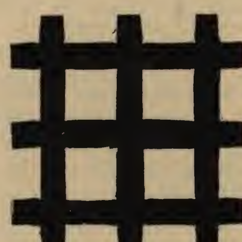
12 Mesh; .047 Wire

In the weaving of the "Cleveland" Double Crimped Wire Cloth, each wire supports and strengthens every other wire, the shoot wires being arched over and under the warp wires, and the warp wires arched over and

40 Mesh; .0135 Wire

under the shoot wires, thus forming a mesh that is absolutely and permanently rigid, eliminating all possibility of wires slipping and insuring an evenness of the screened product. The wires are CRIMPED, not with sharp angles, but curved gradually and gracefully over and under the intersecting wires, without any rough corners. All strain is equally distributed over the entire screen, and the openings remain uniform and equal as long as there remains enough metal to sustain the weight of the material to be screened.

Be sure and give full information when ordering wire cloth. Don't forget to give: Number of rolls, or num-



2½ Mesh. .195 Wire

ber of pieces; length or width of each piece or roll; mesh; decimal size of wire and material from which cloth is to be made.

Large stock always on hand; special mesh manufactured to suit requirements at right prices.

Classified Buyers' Guide

AERIAL TRAMWAYS

LESCHEN, A., & SONS ROPE CO., St. Louis, Mo....................192-296-297
American Steel & Wire Co., Chicago, Ill.
Hazard Mfg. Co., Wilkes-Barre, Pa.
Interstate Equipment Corp., New York.
MacWhyte Co., Kenosha, Wis.
Roebling's Sons Co., John A., Trenton, N. J.
Ruggles Mach. Co., Poultney, Vt.
Universal Conveyor Co., South Bend, Ind.

AGITATORS

MORRIS MACHINE WORKS, Baldwinsville, N. Y...........293-294-295
American Steam Pump Co., Battle Creek, Mich.
Caldwell, W. E., Co., Louisville, Ky.

AIR COMPRESSORS

CHICAGO PNEUMATIC TOOL CO., New York, N. Y..................193-240
American Air Compressor Works, Brooklyn.
Bury Compressor Co., Erie, Pa.
Curtis Pneumatic Machy. Co., St. Louis, Mo.
Domestic Engine & Pump Co., Shippensburg, Pa.
Gardner Governor Co., Quincy, Ill.
Ingersoll-Rand Co., New York, N. Y.
Novo Engine Co., Lansing, Mich.
Schramm, Inc., West Chester, Pa.
Sullivan Machy. Co., Chicago, Ill.
Worthington Pump & Machy. Co., New York.

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Federal Pneumatic System Co., Chicago, Ill.
Gay, Rupert M., New York, N. Y.
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Stroud & Co., E. H., Chicago, Ill.
Sturtevant Mill Co., Boston, Mass.
Universal Road Machy. Co.. Kingston, N. Y.

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International Combustion Engr. Corp., New York, N. Y.
Jeffrey Mfg. Co., Columbus, O.
Portable Machy. Co., Inc., Passaic, N. J.

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SCHAFFER ENGR. & EQUIPMENT CO., Pittsburgh, Pa. 259-274
Automatic Weighing Mach. Co., New York.
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Helmick Foundry-Machine Co., Fairmount, W. Va.
Lobdell Car Wheel Co., Wilmington, Del.
Vulcan Iron Works, Wilkes-Barre, Pa.

BABBITT METAL

Brown, Paul R., Co., New York, N. Y.
Great Western Smelting & Refining Co., St. Louis, Mo.
Magnolia Metal Co., New York, N. Y.
Reeves, Paul S., & Co., Philadelphia, Pa.
Ryerson, Joseph T., & Son, Chicago, Ill.
Union Smelting & Refining Co., Newark, N. J.
United American Metals Corp., Brooklyn.

BAGGING MACHINERY

Bates Valve Bag Co., Chicago, Ill.
Valve Bag Co. of America, Toledo, O.

BAGS, COTTON

Bemis Bros. Bag Co., St. Louis, Mo.
Werthan Bag Co., Nashville, Tenn.

BAGS, PAPER

Adams Bag Co., Cleveland, O.
Bates Valve Bag Co., Chicago, Ill.
Jaite Co., Jaite, O.
Taggart Bros. Co., Watertown, N. Y.
Valve Bag. Co. of America, Toledo, O.

BARGES, STEEL

American Steel Dredge Co., Fort Wayne, Ind.

BARREL MAKING MACHINERY

Associated Cooperage Industries of America, St. Louis, Mo.
Holmes, E. & B., Machy. Co., Buffalo, N. Y.
Stoll, D. H., Co., Inc., Buffalo, N. Y.

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Standard Steel Works, North Kansas City, Mo.

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Sandusky Cooperage & Lumber Co., Toledo.

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Hyatt Roller Bearing Co., Harrison, N. J.
Plamondon, A., Mfg. Co., Chicago, Ill.
Ryerson, Joseph T., & Son, Chicago, Ill.
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Stanley Belting Corp., Chicago, Ill.

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Imperial Belting Co., Chicago, Ill.
Mount Vernon Belting Co., Baltimore, Md.
New York Belting & Packing Co., New York, N. Y.
New York Rubber Co., New York, N. Y.
Quaker City Rubber Co., Philadelphia, Pa.
Republic Belting Co., Baltimore, Md.
Republic Rubber Co., Youngstown, O.
Salisbury, W. H., & Co., Inc., Chicago, Ill.
Sandvik Steel, Inc., New York, N. Y.
Stanley Belting Corp., Chicago, Ill.
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New York Rubber Co., New York, N. Y.
Quaker City Rubber Co., Philadelphia, Pa.
Republic Belting Co., Baltimore, Md.
Republic Rubber Co., Youngstown, O.
Rhoads, J. E., & Sons, Philadelphia, Pa.
Salisbury, W. H., & Co., Chicago, Ill.
Stanley Belting Corp., Chicago, Ill.
United States Rubber Co., New York, N. Y.

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Conveyors Corp. of America, Chicago, Ill.
Harrisburg Mfg. & Boiler Co., New York.
Heltzel Steel Form & Iron Co., Warren, O.
Jeffrey Mfg. Co., Columbus, O.
Manganese Steel Forge Co., Philadelphia.
Seaverns, James B., Chicago, Ill.
Sturtevant Mill Co., Boston, Mass.
Universal Conveyor Co., South Bend, Ind.
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Walsh & Weidner Boiler Co., Chattanooga, Tenn.

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DU PONT DE NEMOURS, E. I. & CO., Wilmington, Del. 262-263
GRASSELLI POWDER CO., Cleveland, O.266
HERCULES POWDER CO., Wilmington, Del. 264-265
Ensign-Bickford Co., Simsbury, Conn.
Giant Powder Co., San Francisco, Cal.
Trojan Powder Co., Allentown, Pa.

BLASTING MACHINES

ATLAS POWDER CO., Wilmington, Del.261
DU PONT DE NEMOURS, E. I. & CO., Wilmington, Del. 262-263
Trojan Powder Co., Allentown, Pa.

BLASTING POWDER

ATLAS POWDER CO., Wilmington, Del.261
DU PONT DE NEMOURS, E. I., & CO., Wilmington, Del. 262-263
GRASSELLI POWDER CO., Cleveland, O.266
HERCULES POWDER CO., Wilmington, Del. 264-265
Giant Powder Co., San Francisco, Cal.
Trojan Powder Co., Allentown, Pa.

BLOCKS, PILLOW

HOWE CHAIN CO., Muskegon, Mich...213
WEBSTER MFG. CO., Chicago, Ill...252-253
Hanson Clutch & Machy. Co., Tiffin, O.
Hill Clutch Co., Cleveland, O.
Plamondon, A., Mfg. Co., Chicago, Ill.

BLOCKS, SHEAVE

Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Hill Clutch Co., Cleveland, O.

BLOWERS

American Blower Co., Detroit, Mich.
Buckeye Blower Co., Columbus, O.
Clements Mfg. Co., Chicago, Ill.
Star Drilling Machine Co., Akron, O.
Sturtevant, B. F., Co., Boston, Mass.

BOILERS

Davis & Sons Co., J. F., Chicago, Ill.
Edge Moor Iron Co., Edge Moor, Del.
Fairbanks Steam Shovel Co., Marion, O.
Freeman Mfg. Co., Racine, Wis.
Harrisburg Mfg. & Boiler Co., New York,
Heine Boiler Co., St. Louis, Mo.
Murray Iron Works Co., Burlington, Iowa.
Vogt, Henry, Machine Co., Louisville, Ky.
Walsh & Weidner Boiler Co., Chattanooga, Tenn.

BUCKET PARTS, MANGANESE

HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282
TAYLOR-WHARTON IRON & STEEL CO., High Bridge, N. J. 210

BUCKETS, CLAM SHELL

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
BAY CITY DREDGE WORKS, Bay City, Mich. 236
LAKEWOOD ENGR. CO., Cleveland, O. 203
LINK-BELT CO., Chicago, Ill. 250-251
MARION STEAM SHOVEL CO., Marion, O. 304-305
NORTHWEST ENGR. CO., Chicago..306-307
Blaw-Knox Co., Pittsburgh, Pa.
Brown Hoisting Machy. Co., Cleveland, O.
Byers Machine Co., Ravenna, O.
Hayward Co., New York, N. Y.
Industrial Works, Bay City, Mich.
Mead-Morrison Mfg. Co., East Boston, Mass.
Owen Bucket Co., Cleveland, O.
Williams, G. H., Co., Erie, Pa.

BUCKETS, CONVEYOR AND ELEVATOR

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
BEAUMONT, R. H. CO., Philadelphia, Pa. 199
GRUENDLER PAT. CRUSHER & PULV. CO., St. Louis, Mo. 221
HENDRICK MFG. CO., Carbondale, Pa. 288
HOWE CHAIN CO., Muskegon, Mich. ..213
LINK-BELT CO., Chicago, Ill. 250-251
MOORE & MOORE, Reading, Pa. 209
MULLINS BODY CORP., Salem, O. 201
WEBSTER MFG. CO., Chicago, Ill. .252-253
WELLER MFG. CO., Chicago, Ill. ...254-303
Biehl Iron Works, Inc., Reading, Pa.
Columbus Conveyor Co., Columbus, O.
Dodge Mfg. Corp. Mushawaka, Ind.
Scheid Engr. Corp., New York, N. Y.
Standard Steel Works, N. Kansas City, Mo.

BUCKETS, GRAB

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
BAY CITY DREDGE WORKS, Bay City, Mich. 286
LINK-BELT CO., Chicago, Ill. 250-251
MARION STEAM SHOVEL CO., Marion, O. 304-305
NORTHWEST ENGR. CO., Chicago.306-307
Blaw-Knox Co., Pittsburgh, Pa.
Byers Machine Co., Ravenna, O.
Industrial Works, Bay City, Mich.
Owen Bucket Co., Cleveland, O.
Williams, G. H., Co., Erie, Pa.

BUILDINGS, PORTABLE

Littleford Bros., Cincinnati, O.
Standard Steel Works, N. Kansas City, Mo.

BURNERS, OIL

BEST, W. N., FURNACE & BURNER CORP., New York, N. Y. 202
Aeroil Burner Co., Union Hill, N. J.
Combustion Engr. Corp., New York, N. Y.
MacLeod Co., Cincinnati, O.

BURR STONES

Munson Mill Machy Co., Utica, N. Y.

CABLEWAYS

GODFREY CONVEYOR CO., Elkhart, Ind. 232
GREEN, L. P. Chicago, Ill. 298
INDIANAPOLIS CABLE EXCAVATOR CO. Indianapolis, Ind. 233
LESCHEN, A. & SONS, ROPE CO., St. Louis, Mo. 192-296-297
LINK-BELT CO., Chicago, Ill. 250-251
SAUERMAN BROS., Chicago, Ill. ...235-300
TREADWELL ENGR. CO., Easton, Pa. 270-271
Flory, S., Mfg. Co., Bangor, Pa.
Roebling's Sons, John A., Co., Trenton, N. J.
Scheid Engr. Corp., New York, N. Y.

CALCINING MACHINERY

BARTLETT, C. O., & SNOW CO., Cleveland, O. 243-249
SCHAFFER ENG. & EQUIPMENT CO. Pittsburgh, Pa. 259-274
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
Butterworth & Lowe, Grand Rapids, Mich.
Love Bros. Inc., Aurora, Ill.

CAR PULLERS, MOVERS

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
LESCHEN, A., & SONS ROPE CO., St. Louis, Mo. 192-296-297
STEPHENS-ADAMSON MFG. CO., Aurora, Ill. 260
WEBSTER MFG. CO., Chicago Ill ..252-253
WELLER MFG. CO., Chicago, Ill. ..254-303
Atlas Car & Mfg. Co., Cleveland, O.
Bay City Foundry & Machine Co., Bay City, Mich.
Carpenter, Geo. B., & Co., Chicago, Ill.
Davidson Equipment Co., O. H., Denver.
Mead-Morrison Mfg. Co., East Boston, Mass.
Mining Machine Co., Mountville, Pa.
Mundy, J. S., Hoisting Engine Co., Newark, N. J.

CAR REPLACERS

HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282
American Chain Co. Inc., Bridgeport, Conn.
Carpenter, Geo. B., & Co., Chicago, Ill.

CAR WHEELS

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
EASTON CAR & CONSTRUCTION CO., New York, N. Y. 204-205
HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282
SANFORD-DAY IRON WORKS, Knoxville, Tenn. 206
Atlas Car & Mfg. Co., Cleveland, O.
Baker Car Co., Harriman, Tenn.
Biehl Iron Works, Inc., Reading, Pa.
Davidson, O. H., Equipment Co., Denver, Colo.
Griffin Wheel Co., Chicago, Ill.
Gustafson Mfg. Co., Chattanooga, Tenn.
Helmick Foundry-Machine Co., Fairmont, W. Va.
Lobdell Car Wheel Co., Wilmington, Del.
Love Bros. Inc., Aurora, Ill.
Webb City and Carterville Fdy. & Machine Wks., Webb City, Mo.

CARS, BOTTOM DUMP

EASTON CAR AND CONSTRUCTION CO., New York, N. Y. 204-205
LAKEWOOD ENGR. CO., Cleveland, O. 203
SANFORD-DAY IRON WORKS, Knoxville, Tenn. 206
TREADWELL ENGR. CO., Easton, Pa. 270-271
Atlas Car & Mfg. Co., Cleveland, O.
Baker Car Co., Harriman, Tenn.
Biehl Iron Works, Inc., Reading, Pa.
Western Wheeled Scraper Co., Aurora, Ill.
Weston, C. J., Fort Dodge, Iowa.

CARS, END DUMP

EASTON CAR AND CONSTRUCTION CO., New York, N. Y. 204-205
LAKEWOOD ENGR. CO., Cleveland, O. .203
SANFORD-DAY IRON WORKS, Knoxville, Tenn. 206
TREADWELL ENGR. CO., Easton, Pa. 270-271
Atlas Car & Mfg. Co., Cleveland, O.
Baker Car Co., Harriman, Tenn.
Biehl Iron Works, Inc., Reading, Pa.
Gustafson Mfg. Co., Chattanooga, Tenn.
Helmick Foundry-Machine Co., Fairmont, W. Va.
Insley Mfg. Co., Indianapolis, Ind.
Kilbourne & Jacobs Mfg. Co., Columbus, O.
Webb City and Carterville Fdy. & Machine Wks., Webb City, Mo.
Western Wheeled Scraper Co., Aurora, Ill.

CARS, GONDOLA

EASTON CAR & CONSTRUCTION CO., New York, N. Y. 204-205
TREADWELL ENGR. CO., Easton, Pa. 270-271
Baker Car Co.. Harriman, Tenn.

CARS, SIDE DUMP

EASTON CAR & CONSTRUCTION CO., New York, N. Y. 204-205
LAKEWOOD ENGR. CO., Cleveland, O. 203
SANFORD-DAY IRON WORKS, Knoxville, Tenn. 206
TREADWELL ENGR. CO., Easton, Pa. 270-271
Atlas Car & Mfg. Co., Cleveland. O.
Baker Car Co., Harriman, Tenn.
Biehl Iron Works, Inc., Reading, Pa.
Continental Car Co. of America, Inc., Louisville, Ky.
Differential Steel Car Co., Findlay, O.
International Clay Machy. Co., Dayton, O.
Kilbourne & Jacobs Mfg. Co., Columbus, O.
Koppel Industrial Car & Equip. Co., Koppel, Pa.
Webb City and Carterville Fdy. & Machine Wks., Webb City, Mo.
Western Wheeled Scraper Co., Aurora, Ill.

CASTINGS, BRASS

Bethlehem Steel Co., Bethlehem, Pa.

CASTINGS, IRON

ERIE PUMP & ENGINE WORKS, Medina, N. Y. 292
NORTMANN-DUFFKE CO., Milwaukee, Wis. 289
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
TAYLOR-WHARTON IRON & STEEL CO., High Bridge, N. J. 210
TREADWELL ENGR. CO., Easton, Pa. 270-271
WEBSTER MFG. CO., Chicago, Ill...252-253
Baker Car Co., Harriman, Tenn.
Bay City Fdy. & Machine Co., Bay City, Mich.
Bethlehem Steel Co., Bethlehem, Pa.
Dobbie Fdy. & Machine Co., Niagara Falls, N. Y.
Hanson Clutch & Machy. Co., Tiffin, O.
Harrisburg Mfg. & Boiler Co., New York.
Indiana Foundry Co., Indiana, Pa.
Lobdell Car Wheel Co., Wilmington, Del.
Love Bros. Inc., Aurora, Ill.

CASTINGS, MANGANESE

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
INLAND ENGR. CO., Chicago, Ill. 208
TAYLOR-WHARTON IRON & STEEL CO., High Bridge, N. J. 210

CASTINGS, NON-FERROUS

Reeves, Paul S. & Co., Philadelphia, Pa.

CASTINGS, STEEL

TAYLOR-WHARTON IRON & STEEL CO., High Bridge, N. J. 210
TREADWELL ENGR. CO., Easton, Pa. 270-271
Bethlehem Steel Co., Bethlehem, Pa.
Lobdell Car Wheel Co., Wilmington, Del.

CHAIN, COIL

COLUMBUS McKINNON CHAIN CO., Columbus, O. 212

CHAIN, CONVEYOR AND ELEVATOR

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
BARTLETT, C. O., & CO., Cleveland, O. 243-249
BENNETT, W. H. K., Chicago, Ill 237
COLUMBUS McKINNON CHAIN CO., Columbus, O. 212
HOWE CHAIN CO., Muskegon, Mich ..213
INLAND ENGR. CO., Chicago, Ill. 208
LINK-BELT CO., Chicago, Ill. 250-251
MOORE & MOORE, Reading, Pa. 209
TAYLOR, S. G. CHAIN CO., Chicago...214
TAYLOR-WHARTON IRON & STEEL CO., High Bridge, N. J. 210
U. S. CHAIN & FORGING CO., Pittsburgh, Pa. 215
WEBSTER MFG. CO., Chicago, Ill. .252-253
WELLER MFG. CO., Chicago, Ill ..254-303
American Chain Co. Inc., Bridgeport, Conn.
Baldwin Chain & Mfg. Co., Worcester, Mass.
Brown Hoisting Machy. Co., Cleveland, O.
Columbus Conveyor Co., Columbus, O.
Diamond Chain & Mfg. Co., Indianapolis, Ind.
Dodge Mfg. Corp. Mishawaka, Ind.
Newhall Chain Forge & Iron Co., New York, N. Y.
Union Chain & Mfg. Co., Sandusky, O.

CHAIN, STEAM SHOVEL AND DREDGE

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
BENNETT, W. H. K., Chicago, Ill 237
COLUMBUS McKINNON CHAIN CO., Columbus, O. 212
HOWE CHAIN CO., Muskegon, Mich ..213
MOORE & MOORE, Reading, Pa. 209
TAYLOR, S. G., CHAIN CO., Chicago, Ill. 214
U. S. CHAIN & FORGING CO., Pittsburgh, Pa. 215
American Chain Co. Inc., Bridgeport, Conn.
Carroll Chain Co., Columbus, O.
Newhall Chain Forge & Iron Co., New York.
Ryerson & Son, Joseph T., Chicago, Ill.
Woodhouse, Wm., Chain Mfg. Co., Edgely, Pa.

CHAIN, TRANSMISSION

HOWE CHAIN CO., Muskegon, Mich ..213
LINK-BELT CO., Chicago, Ill. 250-251
TAYLOR-WHARTON IRON & STEEL CO., High Bridge, N. J. 210
U. S. CHAIN & FORGING CO., Pittsburgh, Pa. 215
WEBSTER MFG. CO., Chicago, Ill. .252-253
WELLER MFG. CO., Chicago, Ill ..254-303
Abell-Howe Co., Chicago, Ill.

American High Speed Chain Co., Indianapolis, Ind.
Baldwin Chain & Mfg. Co., Worcester, Mass.
Diamond Chain & Mfg. Co., Indianapolis, Ind.
Dodge Mfg. Corp. Mishawaka, Ind.
Morse Chain Co., Ithaca, N. Y.
Newhall Chain Forge & Iron Co., New York.
Union Chain & Mfg. Co., Sandusky, O.

CHUTES

(See Bin Gates, Chutes)

CLIPS, WIRE ROPE

LESCHEN, A., & SONS ROPE CO., St. Louis, Mo. 192-296-297
Hazard Mfg. Co., Wilkes-Barre, Pa.
Roebling's Sons Co., John A., Trenton, N. J.

CLUTCHES

WELLER MFG. CO., Chicago, Ill ..254-303
Charter Gas Engine Co., Sterling, Ill.
Dodge Mfg. Corp. Mishawaka, Ind.
Hanson Clutch & Machy. Co., Tiffin, O.
Hill Clutch Co., Cleveland, O.
Plamondon, A., Mfg. Co., Chicago, Ill.

CONES

Allen Cone Co., El Paso, Tex.

CONTROLLERS, AUTOMATIC TEMPERATURE

BRISTOL CO., Waterbury, Conn. 194

CONTROLLERS, ELECTRIC

(See Electric Controllers)

CONVEYORS, APRON

STEPHENS-ADAMSON MFG. CO., Aurora, Ill. 260
WEBSTER MFG. CO., Chicago, Ill...252-253

CONVEYORS, BELT

STEPHENS-ADAMSON MFG. CO., Aurora, Ill. 260
WEBSTER MFG. CO., Chicago, Ill...252-253
WELLER MFG. CO., Chicago, Ill. ..254-303
Barber-Greene Co., Aurora, Ill.
Greenville Mfg. Co., Greenville, O.
Robins Conveying Belt Co., New York, N. Y.
Specialty Engr. Co., Philadelphia, Pa.
Universal Conveyor Co., South Bend, Ind.

CONVEYORS, PERKINS PIVOTED BUCKET

WEBSTER MFG. CO., Chicago, Ill. .252-303

CONVEYORS, PORTABLE

Barber-Greene Co., Aurora, Ill.
Portable Machine Co., Passaic, N. J.

CONVEYORS, SCREW

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
STEPHENS-ADAMSON MFG. CO., Aurora, Ill. 260
WEBSTER MFG. CO., Chicago, Ill. .252-253
Caldwell, H. W., & Son, Chicago, Ill.
Dodge Mfg. Corp. Mishawaka, Ind.

COOLERS

BARTLETT, C. O., & SNOW, Cleveland,. O. 243-249
Reeves Bros. Co., Alliance, O.

COUPLINGS, CAR

EASTON CAR AND CONSTRUCTION CO., New York, N. Y. 204-205
SANFORD-DAY IRON WORKS, Knoxville, Tenn. 206
Baker Car Co., Harriman, Tenn.
Wood Drill Works, Paterson, N. J.

COUPLINGS, HOSE

CLEVELAND ROCK DRILL CO., Cleveland, O. 241
Wood Drill Works, Paterson, N. J.

COUPLINGS, SHAFT

Smith & Serrell, Newark, N. J.

CRANES, ELECTRIC TRAVELING

LINK-BELT CO., Chicago, Ill. 250-251
Abell-Howe Co., Chicago, Ill.
Curtis Pneumatic Machy. Co., St. Louis, Mo.
Euclid Crane & Hoist Co., Euclid, O.
Pawling & Harnischfeger Co., Milwaukee, Wis.
Scheid Engr. Corp., New York, N. Y.
Whiting Corporation, Harvey, Ill.
Yale & Towne Mfg. Co., Stamford, Conn.

CRANES, JIB

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
Chisholm-Moore Mfg. Co., Cleveland, O.
Curtis Pneumatic Machy. Co., St. Louis, Mo.
Industrial Works, Bay City, Mich.
Whiting Corporation, Harvey, Ill.

CRANES, LOCOMOTIVE

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
LINK-BELT CO., Chicago, Ill. 250-251
MARION STEAM SHOVEL CO., Marion, O. 304-305
NORTHWEST ENGR. CO., Chicago, Ill. 306-307
Brown Hoisting Machy. Co., Cleveland, O.
Browning Co., Cleveland, O.
Bucyrus Co., South Milwaukee, Wis.
Byers Machine Co., Ravenna, O.
Erie Steam Shovel Co., Erie, Pa.
Industrial Works, Bay City, Mich.
Moore Bros., Chicago, Ill.
Orton & Steinbrenner Co., Chicago, Ill.
Osgood Co., Marion, O.
Seaverns, James B., Chicago, Ill.
Thew Shovel Co., Lorain, O.
Universal Crane Co., Cleveland, O.

CRANES, OVERHEAD ELECTRIC

Euclid Crane & Hoist Co., Euclid, O.
Pawling & Harnischfeger Co., Milwaukee, Wis.
Whiting Corp., Harvey, Ill.

CRANES, TRACTION

BAY CITY DREDGE WORKS, Bay City, Mich. 236
KOEHRING CO., Milwaukee, Wis. 216
LINK-BELT CO., Chicago, Ill. 250-251
MARION STEAM SHOVEL CO., Marion, O. 304-305
NORTHWEST ENGR. CO., Chicago, 306-307
Austin Machy. Corp., Toledo, O.
Baker, R. & L. Co., Cleveland, O.
Byers Machine Co., Ravenna, O.
McMyler Interstate Co., Cleveland, O.
Michigan Dredge Co., Bay City, Mich.
Orton & Steinbrenner Co., Chicago, Ill.
Pawling & Harnischfeger Co., Milwaukee, Wis.
Penn Bridge Co., New York, N. Y.
Thew Shovel Co., Lorain, O.
Universal Crane Co., Cleveland, O.

CRUSHERS AND PULVERIZERS

Crusher Parts, Manganese Steel

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282
INLAND ENGR. CO., Chicago, Ill. 208
MOORE & MOORE, Reading, Pa. 209
TAYLOR-WHARTON IRON & STEEL CO., High Bridge, N. J. 210

Crushers, Disc

Chalmers & Williams, Chicago Heights, Ill.
Sturtevant Mill Co., Boston, Mass.

Crushers, Gyratory

ALLIS-CHALMERS MFG. CO.,

Milwaukee, Wis. 217
GRUENDLER PAT. CRUSHER & PULV. CO., St. Louis, Mo. 221
KENNEDY-VAN SAUN MFG. & ENGR. CO., New York, N. Y. 224
Austin Mfg. Co., Chicago, Ill.
Austin-Western Road Machy. Co., Chicago.
Denver Engr. Works Co., Denver, Colo.
Morgan Engineering Co. Alliance, O.
Smith Engr. Works, Milwaukee, Wis.
Traylor Engr. & Mfg. Co., Allentown, Pa.

Crushers, Hammer

BARTLETT, C. O., & SNOW CO., Cleveland, O. 243-249
DIXIE MACHY. MFG. CO., St. Louis, Mo. 220
GRUENDLER PAT. CRUSHER & PULV. Co., St. Louis, Mo. 221
K-B PULVERIZER CO., New York.....223
KENNEDY-VAN SAUN MFG. & ENGR. CO., New York, N. Y. 224
PENNSYLVANIA CRUSHER CO., Philadelhpia, Pa. 228-229
WILLIAMS PAT. CRUSHER & PULV. CO., St. Louis, Mo. 230
Jeffrey Mfg. Co., Columbus, O.
Sturtevant Mill Co., Boston, Mass.

Crushers, Jaw

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
GOOD ROADS MACHY. CO., Kennett Square, Pa. 258
GRUENDLER PAT. CRUSHER & PULV. CO., St. Louis, Mo. 221
KENNEDY-VAN SAUN MFG. & ENGR. CO., New York, N. Y. 224
LEWISTOWN FOUNDRY & MACHINE CO., Lewistown, Pa. 225
NEW HOLLAND MACHINE CO., New Holland, Pa. 226
UNIVERSAL CRUSHER CO., Cedar Rapids, Iowa 227
Austin-Western Road Machy. Co., Chicago.
Buchanan, C. Y. & Co., New York, N.Y.
Denver Engr. Works Co., Denver, Colo.
Stroud, E. H., & Co., Chicago, Ill.
Sturtevant Mill Co., Boston, Mass.
Traylor Engr. & Mfg. Co., Allentown, Pa.
Universal Road Machy. Co., Kingston, N. Y.
Webb City and Carterville Fdry. & Machine Works, Webb City, Mo.
Western Wheeled Scraper Co., Aurora, Ill.

Crushers, Rotary

LINK-BELT CO., Chicago, Ill. 250-251
PENNSYLVANIA CRUSHER CO., Philadelphia, Pa. 228-229
Butterworth & Lowe, Grand Rapids, Mich.
Kritzer Co., Chicago, Ill.
Sturtevant Mill Co., Boston, Mass.

Crushers, Single Roll

NEW HOLLAND MACHINE CO., New Holland, Pa. 226
PENNSYLVANIA CRUSHER CO., Philadelphia, Pa. 228-229
McLanahan-Stone Machine Co., Hollidaysburg, Pa.

Mills, Ball and Pebble

HARDINGE CO., New York, N. Y. 222
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
Denver Engr. Works Co., Denver, Colo.
Love Bros, Inc., Aurora, Ill.
Smidth, F. L., & Co., New York, N. Y.

Mills, Conical

HARDINGE CO., New York, N. Y. 222

Mills, Crushing and Grinding

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
DIXIE MACHY. MFG. CO., St. Louis, Mo. 220
HARDINGE CO., New York, N. Y. 222
PENNSYLVANIA CRUSHER CO., Philadelphia, Pa. 228-229
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
WILLIAMS PAT. CRUSHER & PULV. CO., St. Louis, Mo. 230
Aero Pulv. Co., New York, N. Y.
Butterworth & Lowe, Grand Rapids, Mich.
Denver Engr. Works Co., Denver, Colo.
Fuller-Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., Columbus, O.
Munson Mill Machy. Co., Inc., Utica, N. Y.
National Engr. Co., Chicago, Ill.
Raymond Bros. Impact Pulv. Co., Chicago.
Stroud, E. H., & Co., Chicago, Ill.
Sturtevant Mill Co., Boston, Mass.

Mills, Tube

LEWISTOWN FOUNDRY & MACHINE CO., Lewistown, Pa. 225
RUGGLES-COLES ENGR. CO., New York, N. Y. 244
Denver Engr. Works Co., Denver, Colo.
Smidth, F. L., & Co., New York, N. Y.

Pulverizers, Disc

Raymond Bros. Impact Pulv. Co., Chicago.
Sturtevant Mill Co., Boston, Mass.

Pulverizers, Hammer

BARTLETT, C. O., & SNOW CO., Cleveland, O 243-249
DIXIE MACHY. MFG. CO., St. Louis, Mo. 220
GRUENDLER PAT. CRUSHER & PULV. CO.. St. Louis, Mo. 221
K-B PULVERIZER CO., New York, N. Y. 223
UNIVERSAL CRUSHER CO., Cedar Rapids, Iowa 227
WILLIAMS PAT. CRUSHER & PULV. CO., St. Louis, Mo. 230
Jeffrey Mfg. Co., Columbus, O.
Raymond Bros. Impact Pulv. Co., Chicago.
Stroud, E. H., & Co., Chicago, Ill.
Sturtevant Mill Co., Boston, Mass.

Pulverizers, Ring

AMERICAN PULVERIZER CO., St. Louis, Mo. 218
Raymond Bros. Impact Pulv. Co., Chicago.
Sturtevant Mill Co., Boston, Mass.

Pulverizers, Roller

BRADLEY PULVERIZER CO., Allentown, Pa. 219
NEW HOLLAND MACHINE CO., New Holland, Pa. 226
Raymond Bros. Impact Pulv. Co., Chicago.
Sturtevant Mill Co., Boston, Mass.

DERRICK SWINGERS

Byers Machine Co., Ravenna, O.
Flory, S., Mfg. Co., Bangor, Pa.
National Hoisting Engine Co., Harrison, N. J
Novo Engine Co., Lansing, Mich.

DERRICKS, MOTORIZING, HAND

Abell-Howe Co., Chicago, Ill

DERRICKS, PORTABLE

NORTHWEST ENGR. CO., Chicago, Ill. 306-307
Bay City Foundry & Machine Co., Bay City, Mich.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Insley Mfg. Co., Indianapolis, Ind.
Minneapolis Steel & Machy. Co., Minneapolis, Minn.

DERRICKS, REVOLVING

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.

DERRICKS, STIFF LEG

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
National Hoisting Engine Co., Harrison, N. J.

DERRICKS, TRAVELING

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.

DERRICKS, TRIPOD

Dobbie Foundry & Machine Co., Niagara Falls, N. Y.

DEWATERING EQUIPMENT

Allen Cone Co., El Paso, Tex.

DIPPER PARTS

Manganese Special Metal

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282
INLAND ENGR. CO., Chicago, Ill 208
TAYLOR-WHARTON IRON & STEEL CO., High Bridge, N. J. 210

DIPPER TEETH

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
INLAND ENGR. CO., Chicago, Ill. 208
MOORE & MOORE, Reading, Pa. 209
TAYLOR-WHARTON IRON & STEEL CO., High Bridge, N. J. 210

DIPPERS

Steam Shovel and Dredge

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
BAY CITY DREDGE WORKS, Bay City, Mich. 236
HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282
MARION STEAM SHOVEL CO., Marion, O. 304-305
NORTHWEST ENGR. CO., Chicago, Ill. 306-307
TAYLOR-WHARTON IRON & STEEL CO., High Bridge, N. J. 210
American Steel Dredge Co., Fort Wayne, Ind.
Bucyrus Co., South Milwaukee, Wis.
Erie Steam Shovel Co., Erie, Pa.

DRAGLINES, CABLEWAY

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
GODFREY CONVEYOR CO., Elkhart, Ind. 232
GREEN, L. P., Chicago, Ill. 298
INDIANAPOLIS CABLE EXCAVATOR CO., Indianapolis, Ind. 233
LINK-BELT CO., Chicago, Ill. 250-251
PAGE ENGR. CO., Chicago, Ill. 299
SAUERMAN BROS., Chicago, Ill. ...235-300
Mundy, J. S., Hoisting Engine Co., Newark, N. J.
National Hoisting Engine Co., Harrison, N. J.
Schofield-Burkett Construction Co., Macon, Ga.

DRAGLINES, REVOLVING BOOM

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
KOEHRING CO., Milwaukee, Wis. 216
MONIGHAN MACHINE CO., Chicago, Ill. 234
NORTHWEST ENGR. CO., Chicago, Ill. 306-307
Austin Machy. Corp., Toledo, O.
Bucyrus Co., South Milwaukee, Wis.
Erie Steam Shovel Co., Erie, Pa.
Gade, C. L., Excavator Works, Iowa Falls, Iowa.
Michigan Dredge Co., Bay City, Mich.
Osgood Co., Marion, O.
Pawling & Harnischfeger Co., Milwaukee, Wis.

DRAGLINES, SCRAPER

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
BEAUMONT, R. H., CO., Philadelphia, Pa. 199
GREEN, L. P., Chicago, Ill. 298
LINK-BELT CO., Chicago, Ill. 250-351
MONIGHAN MACHINE CO., Chicago, Ill. 234
PAGE ENGR. CO., Chicago, Ill. 299
SAUERMAN BROS., Chicago, Ill. ..235-300
Erie Steam Shovel Co., Erie, Pa.
Novo Engine Co., Lansing, Mich.

DREDGE BOATS

BAY CITY DREDGE WORKS, Bay City, Mich. 238
ELLICOTT MACHINE CORP., Baltimore, Md. 238
MORRIS MACHINE WORKS, Baldwinsville, N. Y. 293-294-295
American Steel Dredge Co., Fort Wayne, Ind.
Bucyrus Co., South Milwaukee, Wis.
Randolph-Perkins Co., Chicago, Ill.

DREDGES, DIPPER

BAY CITY DREDGE WORKS, Bay City. Mich. 236
MARION STEAM SHOVEL CO., Marion, O. 304-305
American Steel Dredge Co., Fort Wayne, Ind.
Fairbanks Steam Shovel Co., Marion, O.
Michigan Dredge Co., Bay City, Mich.
Osgood Co., Marion, O.

DREDGES, LAND

BAY CITY DREDGE WORKS, Bay City, Mich. 236
MARION STEAM SHOVEL CO., Marion, O. 304-305
NORTHWEST ENGR. CO., Chicago..306-307
American Steel Dredge Co., Fort Wayne, Ind.
Michigan Dredge Co., Bay City, Mich.

DREDGES, SAND SUCTION

BENNETT, W. H. K., Chicago, Ill. ...237
ELLICOTT MACHINE CORP., Baltimore, Md. 238
ERIE PUMP & ENGINE WORKS, Medina, N. Y. 292
MORRIS MACHINE WORKS, Baldwinsville, N. Y. 293-294-295
Bucyrus Co., South Milwaukee, Wis.
Fairbanks Steam Shovel Co., Marion, O.
Randolph-Perkins Co., Chicago, Ill.

DRILL SHARPENING MACHINERY

CHICAGO PNEUMATIC TOOL CO., New York, N. Y. 193-240
Denver Rock Drill Mfg. Co., Denver, Colo.
Sullivan Machy. Co., Chicago, Ill.
Wood Drill Works, Paterson, N. J.

DRILL STEEL

Crucible Steel Co., New York, N. Y.
Milne, A., & Co., Chicago, Ill.

DRILLING CONTRACTORS

Pennsylvania Drilling Co., Pittsburg, Pa.

DRILLS, BLAST HOLE

ARMSTRONG MFG. CO., Waterloo, Iowa 239

SANDERSON-CYCLONE DRILL CO., Orrville, O. 242
American Well Works, Aurora, Ill.
Cochise Machine Co., Los Angeles, Calif.
Howells Mining Drill Co., Plymouth, Pa.
Star Drilling Machine Co., Akron, O.

DRILLS, HAND HAMMER

CHICAGO PNEUMATIC TOOL CO., New York, N. Y. 193-240
CLEVELAND ROCK DRILL CO., Cleveland, O. 241
Denver Rock Drill Mfg. Co., Denver, Colo.
Hardsocg Wonder Drill Co., Ottumwa, Iowa.
Ingersoll-Rand Co., New York, N. Y.
Sullivan Machy. Co., Chicago, Ill.
Wood Drill Works, Paterson, N. J.

DRILLS, SECONDARY

CLEVELAND ROCK DRILL CO., Cleveland, O. 241
Denver Rock Drill Mfg. Co., Denver, Colo.
Pneumelectric Corp., Syracuse, N. Y.
Sullivan Machy. Co., Chicago, Ill.

DRILLS, TRIPOD

Denver Rock Drill Mfg. Co., Denver, Colo.
Howells Mining Drill Co., Plymouth, Pa.
Ingersoll-Rand Co., New York, N. Y.
Pneumelectric Corp., Syracuse, N. Y.
Sullivan Machy. Co., Chicago, Ill.
Wood Drill Works, Paterson, N. J.

DRUMS

(See Barrels, Steel)

DRY PANS

National Engr. Co., New York, N. Y.

DRYERS, CEMENT

STEACY-SCHMIDT MFG. CO., New York, N. Y. 276

DRYERS, LIME

BARTLETT, C. O., & SNOW CO., Cleveland, O. 243-249
HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282
HENDRICK MFG. CO., Carbondale, Pa..288
RUGGLES-COLES ENGR. CO., New York, N. Y. 244
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
American Process Co., New York, N. Y.

DRYERS, PLASTER

RUGGLES-COLES ENGR. CO., New York, N. Y. 244
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276

DRYERS, SAND

BARTLETT, C. O., & SNOW CO., Cleveland, O. 243-249
HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282
HENDRICK MFG. CO., Carbondale, Pa..288
LEWISTOWN FOUNDRY & MACHINE CO., Lewistown, Pa. 225
RUGGLES-COLES ENGR. CO., New York, N. Y. 244
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
American Process Co., New York, N. Y.
Bacon, Earle C., New York, N. Y.
Buckeye Dryer Co., Chicago, Ill.
Indiana Foundry Co., Indiana, Pa.
Walsh & Weidner Boiler Co., Chattanooga, Tenn.

DRYERS, STONE

BARTLETT, C. O., & SNOW CO., Cleveland, O. 243-249
HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282
HENDRICK MFG. CO., Carbondale, Pa..288
RUGGLES-COLES ENGR. CO., New York, N. Y. 244
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
American Process Co., New York, N. Y.
Reeves Bros. Co., Alliance, O.

DUST COLLECTING SYSTEMS

CLARK DUST COLLECTING CO., Chicago, Ill. 245
GRUENDLER PAT. CRUSHER & PULV. CO., St. Louis, Mo. 221
NORTHERN BLOWER CO., Cleveland..246
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
Buckeye Blower Co., Columbus, O.
Buffalo Forge Co., Buffalo, N. Y.
Federal Pneumatic Systems Co., Chicago, Ill.
Stroud & Co., E. H., Chicago, Ill.

DYNAMITE

(See Explosives)

ELECTRIC CONTROLLERS

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
WESTINGHOUSE ELECTRIC & MFG. CO., E. Pittsburg, Pa. 248
Electric Controller & Mfg. Co., Cleveland, O.
Goodman Mfg. Co., Chicago, Ill.

ELECTRIC CONVERTERS

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
WESTINGHOUSE ELECTRIC & MFG. CO., E. Pittsburgh, Pa. 248
Wagner Electric Corp., St. Louis, Mo.

ELECTRIC DYNAMOS

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
WESTINGHOUSE ELECTRIC & MFG. CO., E. Pittsburgh, Pa. 248
Burke Electric Co., Erie, Pa.
Fairbanks-Morse Co., Chicago, Ill.
Reliance Electric & Engr. Co., Cleveland, O.

ELECTRIC FUSES

DAUM, A. F., & CO., Pittsburgh, Pa...267

ELECTRIC GENERATOR SETS

CLIMAX ENGR. CO., Clinton, Iowa....256

ELECTRIC GENERATORS

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
WESTINGHOUSE ELECTRIC & MFG. CO., E. Pittsburgh, Pa. 248
Burke Electric Co., Erie, Pa.
Fairbanks-Morse Co., Chicago, Ill.
Reliance Electric & Engr. Co., Cleveland, O.
Wagner Electric Corp., St. Louis, Mo.

ELECTRIC MOTORS

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
WESTINGHOUSE ELECTRIC & MFG. CO., E. Pittsburgh, Pa. 248
Burke Electric Co., Erie, Pa.
Davidson, O. H., Equipment Co., Denver, Colo.
Fairbanks-Morse Co., Chicago, Ill.
Reliance Electric & Engr. Co., Cleveland, O.
Wagner Electric Corp., St. Louis, Mo.

ELECTRIC TRANSFORMERS

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
KUHLMAN ELECTRIC CO., Bay City, Mich. 247
WESTINGHOUSE ELECTRIC & MFG. CO., E. Pittsburgh, Pa. 248
Davidson, O. H., Equipment Co., Denver, Colo.
Electric Controller & Mfg. Co., Cleveland, O.
Wagner Electric Corp., St. Louis, Mo.

ELEVATOR PARTS, MANGANESE STEEL

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
TAYLOR-WHARTON IRON & STEEL CO., High Bridge, N. J. 210

ELEVATORS, BUCKET

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
BARTLETT, C. O., & SNOW CO., Cleveland, O. 243-249
BEAUMONT, R. H., CO., Philadelphia, Pa. 199
GOOD ROADS MACHY. CO., Kennett Square, Pa. 258
GRUENDLER PAT. CRUSHER & PULV. CO., St. Louis, Mo. 221
HOWE CHAIN CO., Muskegon, Mich. 213
SAUERMAN BROS., Chicago, Ill. ..235-300
SCHAFFER ENGR. & EQUIPMENT CO., Pittsburgh, Pa. 259-274
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
STEPHENS-ADAMSON MFG. CO., Aurora, Ill. 260
UNIVERSAL CRUSHER CO., Cedar Rapids, Iowa 227
WEBSTER MFG. CO., Chicago, Ill. 252-253
WELLER MFG. CO., Chicago, Ill. .254-303
WILLIAMS PAT. CRUSHER & PULV. CO., St. Louis, Mo. 230
Columbus Conveyor Co., Columbus, O.
Greenville, Mfg. Co., Greenville, O.
Specialty Engr. Co., Philadelphia, Pa.
Sturtevant Mill Co., Boston, Mass.
Universal Road Machy. Co., Kingston, N. Y.

ELEVATORS, PIVOTED BUCKET

WEBSTER MFG. CO., Chicago, Ill...252-253

ENGINE GENERATOR SETS

CLIMAX ENGR. CO., Clinton, Iowa....256

ENGINEERS, DESIGNING & CONSULTING

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
ARNOLD & WEIGEL, Woodville, O. 257-275
GOOD ROADS MACHY. CO., Kennett Square, Pa. 258
NORTHERN BLOWER CO., Cleveland 246
SCHAFFER ENGR. & EQUIPMENT CO., St. Louis, Mo. 259-274
Besser Sales Co., Chicago, Ill.
Bland Engr. Co., Minneapolis, Minn.
Buckbee, J. C., Co., Chicago, Ill.
Burd & Giffels, Grand Rapids, Mich.
Denver Engr. Works Co., Denver, Colo.
Greenville Mfg. Co., Greenville, O.
Guarantee Construction Co., New York, N. Y.
Hauer, Daniel, J., Baltimore, Md.
Hunt, Robt. W., Chicago, Ill.
Jett & Stiemke, Milwaukee, Wis.
Kritzer Co., Chicago, Ill.
MacDonald Engr. Co., Chicago, Ill.
Meade, Richard K., & Co., Baltimore, Md.
Randolph-Perkins Co., Chicago, Ill.
Scheid Engr. Corp., New York, N. Y.
Smidth, F. L., & Co., New York, N. Y.
Specialty Engr. Co., Philadelphia, Pa.

ENGINES, GASOLINE

ARMSTRONG MFG. CO., Waterloo, Iowa 239
BEAVER MFG. CO., Milwaukee, Wis...255
CHICAGO PNEUMATIC TOOL CO., New York, N. Y. 193-240
CLIMAX ENGR. CO., Clinton, Iowa....256
EASTON CAR AND CONSTRUCTION CO., New York, N. Y. 204-205
ERIE PUMP & ENGINE WORKS, Medina, N. Y. 292
GREEN, L. P., Chicago, Ill. 298
HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282
SANDERSON-CYCLONE DRILL CO., Orrville, O. 242
Charter Gas Engine Co., Sterling, Ill.
Fairbanks-Morse Co., Chicago, Ill.
Midwest Engine Corp., Indianapolis, Ind.
Minneapolis Steel & Machy. Co., Minneapolis, Minn.
Novo Engine Co., Lansing, Mich. ..
Schramm, Inc., West Chester, Pa.
Universal Motor Co., Oshkosh, Wis.
Waukesha Motor Co. ,Waukesha, Wis.
Wisconsin Motor Mfg. Co., Milwaukee, Wis.

ENGINES, HOISTING

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
CHICAGO PNEUMATIC TOOL CO., New York, N. Y. 193-240
GREEN, L. P., Chicago, Ill. 298
Byers Machine Co., Ravenna, O.
Denver Engr. Works Co., Denver, O.
Flory, S., Mfg. Co., Bangor, Pa.
Mead-Morrison Mfg. Co., E. Boston, Mass.
Michigan Dredge Co., Bay City, Mich.
Minneapolis Steel & Machy. Co., Minneapolis, Minn.
Mundy Hoisting Engine Co., J. S., Newark, N. J.
National Hoisting Engine Co., Harrison, N. J.
Novo Engine Co., Lansing, Mich.
Vulcan Iron Works Co., Denver, Colo.

ENGINES, KEROSENE

BEAVER MFG. CO., Milwaukee, Wis...255
CLIMAX ENGR. CO., Clinton, Iowa ...256

ENGINES, OIL

BENNETT, W. H. K., Chicago, Ill. 237
CHICAGO PNEUMATIC TOOL CO., New York, N. Y. 193-240
GREEN, L. P., Chicago, Ill. 298
Anderson Foundry & Machine Co., Anderson, Ind.
Buckeye Machine Co., Lima, O.
Charter Gas Engine Co., Sterling, Ill.
Fairbanks-Morse Co., Chicago, Ill.
Ingersoll-Rand Co., New York, N. Y.
Minneapolis Steel & Machy. Co., Minneapolis Minn.
Power Mfg. Co., Marion, O.
Randolph-Perkins Co., Chicago, Ill.
St. Mary's Oil Engine Co., St. Charles, Mo.
Venn-Severin Machine Co., Chicago, Ill.

ENGINES, STEAM

GREEN, L. P., Chicago, Ill. 298
ELLICOTT MACHINE CORP., Baltimore, Md. 238
ERIE PUMP & ENGINE WORKS, Medina, N. Y. 292
MORRIS MACHINE WORKS, Baldwinsville, N. Y. 293-294-295
SANDERSON-CYCLONE DRILL CO., Orrville, O. 242
Automatic Furnace Co., Dayton, O.
Byers Machine Co., Ravenna, O.
Michigan Dredge Co., Bay City, Mich.
Murray Iron Works Co., Burlington, Iowa.

EXPLOSIVES

ATLAS POWDER CO., Wilmington, Del. 261
DU PONT DE NEMOURS, E. I., & CO. Wilmington, Del. 262-263
GRASSELLI POWDER CO., Cleveland 266
HERCULES POWDER CO., Wilmington, Del. 264-265
Giant Powder Co., San Francisco, Cal.
Trojan Powder Co., Allentown, Pa.

FANS

Buckeye Blower Co., Columbus, O.
Buffalo Forge Co., Buffalo, N. Y.

Raymond Bros., Impact Pulv. Co., Chicago, Ill.
Vulcan Iron Works, Co., Denver, Colo.

FEEDERS

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
BARTLETT, C. O., & SNOW CO., Cleveland, O. 243-249
SCHAFFER ENGR. & EQUIPMENT, CO., Pittsburgh, Pa. 259-274
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
WELLER MFG. CO., Chicago, Ill. ..254-303
Automatic Furnace Co., Dayton, O.
Columbus Conveyor Co., Columbus, O.
National Engr. Co., Chicago, Illl.
Raymond Bros., Impact Pulv. Co., Chicago.

FIRE BRICK

Chicago Fire Brick Co., Chicago, Ill.

FORGES

Buffalo Forge Co., Buffalo, N. Y.

FUSES, BLASTING

Ensign-Bickford Co., Simsbury, Conn.

FUSES, ELECTRICAL

(See Electric Fuses)
AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
GODFREY CONVEYOR CO., Elkhart, Ind. 232
HADFIELD-PENFIELD CO., Bucyrus, O. 207-282
INLAND ENGR. CO., Chicago, Illl. 208
MOORE & MOORE, Reading, Pa. 209
SCHAFFER ENGR. & EQUIPMENT CO., Pittsburgh, Pa. 259-274
TAYLOR-WHARTON IRON & STEEL CO., High Bridge, N. J. 210
WELLER MFG. CO., Chicago, Ill. ..254-303
Cleveland Worm & Gear Co., Cleveland, O.
Fawcus Machine Co., Pittsburgh, Pa.
Hill Clutch Co., Cleveland, O.
Plamondon, A., Mfg. Co., Chicago, Ill.
Tool Steel Gear & Pinion Co., Cincinnati, O.

GRATES

KRAMER BROS., FOUNDRY CO., Dayton, O. 268
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
Automatic Furnace Co., Dayton, O.
Indiana Foundry Co., Indiana, Pa.
International Combustion Engr. Corp., New York, N. Y.
Martin Grate Co., Chicago, Ill.
Murray Iron Works Co., Burlington, Iowa.

GREASE

SANFORD-DAY IRON WORKS, Knoxville, Tenn. 206
Cook's, Adam, Sons, Inc., New York, N. Y.
Keystone Lubricating Co., Philadelphia, Pa.
Ohio Grease Co., Loudonville, O.

HOISTS, AIR

Curtis Pneumatic Machy. Co., St. Louis, Mo.

HOISTS, CHAIN

Abell-Howe Co., Chicago, Ill.
Carpenter, Geo. B., Co., Chicago, Ill.
Chisholm-Moore Mfg. Co., Cleveland, O.
Yale & Town Mfg. Co., Stamford, Conn.

HOISTS, DERRICK

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
MARION STEAM SHOVEL CO., Marion, O. 304-305
NORTHWEST ENGR. CO., Chicago..306-307
Bay City Foundry & Machine Co., Bay City, Mich.
Byers Machine Co., Ravenna, O.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Euclid Crane & Hoist Co., Euclid, O.
Flory S., Mfg. Co., Bangor, Pa.
Mundy, J. S., Hoisting Engine Co., Newark, N. J.

HOISTS, DRUM

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
BEAUMONT, R. H., CO., Elkhart, Ind. 199
GREEN, L. P., Chicago, Ill. 298
LINK-BELT CO., Chicago, Ill. 250-251
MARION STEAM SHOVEL CO., Marion, O. 304-305
MORRIS MACHINE WORKS, Baldwinsville, N. Y. 293-294-295
SAUERMAN BROS., Chicago, Ill. ..235-300
THOMAS ELEVATOR CO., Chicago, Ill. 272
TREADWELL ENGR. CO., Easton, Pa. 270-271
Bay City Foundry & Machine Co., Bay City, Mich.
Byers Machine Co., Ravenna, O.
Clyde Iron Works, Sales Co., Duluth, Minn.
Denver Engr. Works, Denver, Colo.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Erie Hoist Co., Erie, Pa.
Euclid Crane & Hoist Co., Euclid, O.
Lidgerwood Mfg. Co., New York, N. Y.
Mead-Morrison Mfg. Co., E. Boston, Mass.
Mundy, J. S., Hoisting Engine Co., Newark, N. J.
Scheid Eng. Corp., New York, N. Y.
Schram, Inc., West Chester, Pa.
Sullivan, Machy. Co., Chicago, Ill.
Universal Hoist & Mfg. Co., Cedar Falls, Iowa.
Vulcan Iron Works Co., Denver, Colo.
Yale & Towne Mfg. Co., Stamford, Conn.

HOISTS, MOTOR TRUCK BODY

VAN DORN IRON WORKS CO., Cleveland, O. 286
Columbia Steel Tank Co., Kansas City, Mo.
Heil Co., Milwaukee, Wis.
Mansfield Steel Corp., Detroit, Mich.
Wood Hydraulic Hoist & Body Co., Detroit, Mich.

HOPPERS

EASTON CAR AND CONSTRUCTION CO., New York, N. Y. 204-205
LINK-BELT CO., Chicago, Ill. 250-251
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
WEBSTER MFG. CO., Chicago, Ill...252-253
WELLER MFG. O., Chicago, Ill.....254-303
International Combustion Engr. Corp., New York, N. Y.

HOSE, AIR, STEAM, WATER

CHICAGO PNEUMATIC TOOL CO., New York, N. Y. 193-240
CINCINNATI RUBBER MFG. CO., Cincinnati, O. 273
CLEVELAND ROCK DRILL CO., Cleveland, O. 241
GOODRICH, B. F., RUBBER CO., Akron, O. 197
Goodyear Tire & Rubber Co., Inc., Akron, O.
New York Belting & Packing Co., New York.
Wood Drill Works, Paterson, N. J.

HOSE, SAND SUCTION

GOODRICH, B. F., CO., Akron, O. 197
MORRIS MACHINE WORKS, Baldwinsville, N. Y. 293-294-295
New York Rubber Co., New York, N. Y.
Quaker City Rubber Co., Philadelphia, Pa.
Republic Rubber Co., Youngstown, O.
Salisbury, W. H., & Co., Chicago, Ill.
U. S. Rubber Co., New York, N. Y.

HULLS, STEEL SECTIONAL

American Steel Dredge Co., Fort Wayne, Ind.

HYDRATORS

SCHAFFER ENGR. & EQUIPMENT CO., Pittsburgh, Pa. 259-274
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
TOEPFER & SONS, Milwaukee, Wis. ..301
Kritzer Co., Chicago, Ill.
Miscampbell, H., Duluth, Minn.

HYDRAULIC PIPE

BENNETT, W. H. K., Chicago, Ill. 237
ELLICOTT MACHINE CORP., Baltimore, Md. 238
ERIE PUMP & ENGINE WORKS, Medina, N. Y. 292
HENDRICK MFG. CO., Carbondale, Pa. 288
MORRIS MACHINE WORKS, Baldwinsville, N. Y. 293-294-296
American Spiral Pipe Works, Chicago, Ill.
Robertson Bros., Chicago, Ill.

HYDRAULIC VALVES

Aldrich Pump Co., Allentown, Pa.
Kelly & Jones Co., Greensburg, Pa.
Republic Rubber Co., Youngstown, O.

INDICATORS, GAUGES AND RECORDING INSTRUMENTS

Detroit Lubricator Co., Detroit, Mich.
Uehling Instrument Co., Paterson, N. J.

KETTLES, CALCINING

(See Calcining Machinery)

KILN LININGS

STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
Chicago Fire Brick Co., Chicago, Ill.

KILNS, CEMENT

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
SCHAFFER ENGR. & EQUIPMENT CO., Pittsburgh, Pa. 259-274
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
Denver Eng. Works Co., Denver, Colo.
Reeves Bros., Co., Alliance, O.
Smidth, F. L., & Co., New York, N. Y.

KILNS, LIME

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. 217
ARNOLD & WEIGEL, Woodville, O. 257-275
HENDRICK MFG. CO., Carbondale, Pa. 288
SCHAFFER ENGR. & EQUIPMENT CO., Pittsburgh, Pa. 259-274
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
Denver Engr. Works, Co., Denver, Colo.
Glamorgan Pipe & Fdy. Co., Lynchburg, Va.
Kritzer Co., Chicago, Ill.
McGann Mfg. Co., York, Pa.

LABORATORY CRUSHERS

DIXIE MACHY. CO., St. Louis, Mo.....220
WILLIAMS PAT. CRUSHER & PULV. CO., St. Louis, Mo. 230
Abbe Eng. Co., New York, N. Y.
Braun Corp., Los Angeles, Cal.

LABORATORY MILLS

DIXIE MACHY. CO., St. Louis, Mo. 220
WILLIAMS PAT. CRUSHER & PULV. CO., St. Louis Mo. 230
Abbe Eng. Co., New York, N. Y.

LABORATORY PULVERIZERS

DIXIE MACHY. CO., St. Louis, Mo. 220
WILLIAMS PAT. CRUSHER & PULV. CO., St. Louis, Mo. 230
Abbe Eng. Co., New York, N. Y.

LABORATORY SCREENS

CLEVELAND WIRE CLOTH & MFG. CO., Cleveland, O. 309
WILLIAMS PAT. CRUSHER & PULV. CO., St. Louis, Mo. 230
Braun Corp., Los Angeles, Cal.
Harrington & King Perforating Co., Chicago, Ill.
National Engr. Co., Chicago, Ill.
Newark Wire Cloth Co., Newark, N. J.

LABORATORY VACUUM PUMPS

Abbe Engr. Co., New York, N. Y.

LIGHTS, ACETYLENE

CARBIC MFG. CO., Duluth, Minn. 277
Milburn, Alexander Co., Baltimore, Md.

LIGHTS, ELECTRIC FLOOD

Moon Mfg. Co., Chicago, Ill.

LIGHTS, PORTABLE

CARBIC MFG. CO., Duluth, Minn. 277

LOADERS AND UNLOADERS, BIN, PORTABLE

EASTON CAR AND CONSTRUCTION CO., New York, N. Y. 204-205
HAISS, GEO., MFG. CO., INC., New York, N. Y. 278-279
LINK-BELT CO., Chicago, Ill. 250-251
NORTHWEST ENGR. CO., Chicago 306-307
WELLER MFG. CO., Chicago, Ill. ..254-303
Atlas Engr. Co., Milwaukee, Wis.
Barber-Greene Co., Aurora, Ill.
Jeffrey Mfg. Co., Columbus, O.
Portable Machy. Co., Inc., Passaic N. J.
Seaverns, James B., Chicago, Ill.
Specialty Engr. Co., Philadelphia, Pa.
Universal Road Machy. Co., Kingston, N. Y.
Western Wheeled Scraper Co., Aurora, Ill.

LOADERS AND UNLOADERS, BOOM AND BUCKET

MARION STEAM SHOVEL CO., Marion, O. 304-305
NORTHWEST ENGR. CO., Chicago 306-307
Austin Machy. Corp., Toledo, O.
Brown Hoisting Machy. Co., Cleveland, O.
Erie Steam Shovel Co., Erie, Pa.
Jeffrey Mfg. Co., Columbus, O.

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WELLER MFG. CO., Chicago, Ill. ..254-303
Atlas Engr. Co., Milwaukee, Wis.
Barber-Greene Co., Aurora, Ill.
Guarantee Construction Co., New York, N. Y.
Jeffrey Mfg. Co., Columbus, O.
Lee Trailer & Body Co., Chicago, Ill.
Portable Machy. Co., Inc., Passaic, N. J.

LOADERS AND UNLOADERS, CONVEYOR

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BEAUMONT, R. H., CO., Philadelphia 199
HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282
HAISS, GEO., MFG. CO., INC., New York, N. Y. 278-279
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Atlas Engr. Co., Milwaukee, Wis.
Austin Machy. Co., Toledo, O.

Barber-Greene Co., Aurora, Ill.
Brown Hoisting Machy. Co., Cleveland, O.
Columbus Conveyor Co., Columbus, O.
Jeffrey Mfg. Co., Columbus, O.
Portable Machy. o., Inc, Passaic, N. J.
Stiles Mfg. Co., Bolivar, Mo.
Universal Conveyor Co., South Bend, Ind.
Western Wheeled Scraper Co., Aurora, Ill.
Weston, C. J., Fort Dodge, Iowa.

LOADERS AND UNLOADERS, HOPPER

BARTLETT, C. O., & SNOW CO., Cleveland, O. 243-249
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WEBSTER MFG. CO., Chicago, Ill. 252-253
WELLER MFG. CO., Chicago, Illl. 254-302
Atlas Engr. Co., Milwaukee, Wis.
Barber-Greene Co., Aurora, Illl.
Lee Trailer & Body Co., Chicago, Ill.
Merchant Shipbuilding Corp., Chester, Pa.
Nelson, N. P., Iron Works, Brooklyn, N. Y.
Portable Machy. Co., Inc., Passaic, N. J.
Smith, T. L., Co., Milwaukee, Wis.
Sunbury Mfg. Co., Sunbury, O.
Weston, C. J., Fort Dodge, Iowa.

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Atlas Car & Mfg. Co., Cleveland, O.
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LUBRICATORS

Detroit Lubricator Co., Detroit, Mich.
Ohio Grease Co., Loudonville, O.

MACHINE SHOP EQUIPMENT

TREADWELL ENG., CO., Easton, Pa. 270-271

MAGNETIC SEPARATORS

Dings Magnetic Separator Co., Milwaukee.
Electric Controller & Mfg. Co., Cleveland, O.
Magnetic Mfg. Co., Milwaukee, Wis.

MIXERS, PLASTER

BARTLETT, C. O., & SNOW CO., Cleveland, O. 243-249
SCHAFFER ENGR. & EQUIPMENT CO., Pittsburgh, Pa. 259-274

MIXERS, SAND

BARTLETT, C. O., & SNOW CO., Cleveland, O. 243-249
SCHAFFER ENGR., & EQUIPMENT, CO. Pittsburgh, Pa. 259-274
Austin Machy. Corp., Toledo, O.

MOTOR TRUCK BODIES

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Acme Motor Truck Co., Cadillac, Mich.
American Truck & Body Co., Martinsville, Va.
Columbian Steel Tank Co., Kansas City, Mo.
Garford Motor Truck Co., Lima, O.
General Motors Truck Co., Pontiac, Mich.
Griscomb-Russel Co., New York, N. Y.
Heil Co., Milwaukee, Wis.
Highway Trailer Co., Edgerton, Wis.
Lee Trailer & Body Co., Chicago, Ill.
Mansfield Steel Corp., Detroit, Mich.
Republic Truck Sales Corp., Alma, Mich.
Wood Hydraulic Hoist & Body Co., Detroit.

MOTOR TRUCKS

Acme Motor Truck Co., Cadillac, Mich.
Armleder Motor Truck Co., Cincinnati, O.
Diamond T Motor Co., Chicago, Ill.
Four Wheel Drive Auto Co., Clintonville. Wis.
Garford Motor Truck Co., Pontiac, Mich.
Minneapolis Steel & Machy. Co., Minneapolis, Minn.
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Kelly & Jones Co., Greensburg, Pa.

PIPE AND FITTINGS, SPIRAL

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MORRIS MACHINE WORKS, Baldwinsville, N. Y. 293-294-295
American Spiral Pipe Works, Chicago, Ill.

PIPE AND FITTINGS, STEEL

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Hill Clutch Co., Cleveland, O.
Philips Pressed Steel Pulley Wks., Philadelphia, Pa.
Plamondon, A., Mfg. Co., Chicago, Ill.
Smidth, F. L., & Co., New York, N. Y.

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American Steam Pump Co., Battle Creek, Mich.
American Well Works, Aurora, Ill.
Buffalo Steam Pump Co., Buffalo, N. Y.
Evinrude Motor Co., Milwaukee, Wis.
Fairbanks-Morse Co., Chicago, Ill.
Ingersoll-Rand Co., New York, N. Y.
Midwest Engine Corp., Indianapolis, Ind.
Schramm, Inc., West Chester, Pa.

PUMPS, DIAPHRAM

Edson Mfg. Corp., Boston, Mass.

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American Steam Pump Co., Battle Creek, Mich.
American Well Works, Aurora, Ill.
Buffalo Steam Pump Co., Buffalo, N. Y.
Emerson Pump & Valve Co., Alexandria, Va.
Evinrude Motor Co., Milwaukee, Wis.
Fairbanks-Morse Co., Chicago, Ill.
Gardner Governor Co., Quincy, Ill.
Midwest Engine Corp., Indianapolis, Ind.
Myers, F. E., & Bros. Co., Ashland, O.

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Aldrich Pump Co., Allentown, Pa.
Gardner Governor Co., Quincy, Ill.
Kansas City Hay Press & Tractor Co., Kansas City, Mo.
Randolph-Perkins Co., Chicago, Ill.
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Gardner Governor Co., Quincy, I'l.

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American Well Works, Aurora, Ill.
Buffalo Steam Pump Co., Buffalo, N. Y.
Emerson Pump & Valve Co., Alexandria, Va.
Fairbanks-Morse Co., Chicago, Ill.
Gardner Governor Co., Quincy, Ill.
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Carpenter, Geo. B., & Co., Chicago, Ill.
Hazard Mfg. Co., Wilkes-Barre, Pa.
MacWhyte Co., Kenosha, Wis.
Roebling's Sons, John A., Co., Trenton, N. J.
Waterbury Co., New York, N. Y.
Williamsport Wire Rope Co., Williamsport, Pa.

SAFETY APPLIANCES, MINE

Mine Safety Appliances Co., Pittsburgh, Pa.

SAND SETTLING TANKS

LINK-BELT CO., Chicago, Ill. 250-251
STEPHENS-ADAMSON MFG. CO., Aurora, Ill. 260
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SCALES, PLATFORM

MEYER, EDWIN A., SALES CO., Newark, N. J. 290
Fairbanks-Morse Co., Chicago, Ill.
Merrick Scale Mfg. Co., Passaic, N. J.

SCALES, TRACK

SCHAFFER ENGR. & EQUIPMENT CO., Pittsburgh, Pa. 259-274
Fairbanks-Morse Co., Chicago, Ill.

SCALES, WAGON

MEYER, EDWIN A., SALES CO., Newark, N. J. 290
Fairbanks-Morse Co., Chicago, Ill.

SCRAPERS, DRAG ROAD

Austin-Western Road Machy. Co., Chicago.
Stiles Mfg. Co., Bolivar, Mo.
Western Wheeled Scraper Co., Aurora, Ill.

SCRAPERS, POWER DRAG

L. P. GREEN, Chicago, Ill. 298
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Beach Mfg. Co., Charlotte, Mich.
Mansfield Engr. Co., Indianapolis, Ind.
Schofield-Burkett Construction Co., Macon, Ga.
Smith, T. L., Co., Milwaukee, Wis.

SCRAPERS, WHEEL ROAD

Austin-Western Road Machinery Co., Chicago, Ill.
Western Wheeled Scraper Co., Aurora, Ill.

SCREEN PARTS

HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282

SCREENS, GRIZZLY

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Austin-Western Road Machy. Co., Chicago.
Manganese Steel Forge Co., Philadelphia, Pa.
Robins Conveying Belt Co., New York, N. Y.
Traylor Engr. & Mfg. Co., Allentown, Pa.
Webb City and Carterville Fdy. & Mach. Wks., Webb City, Mo.
Western Wheeled Scraper Co., Aurora, Ill.

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Archer Iron Works, Chicago, Ill.
Audubon Wire Cloth Co., Inc., Audubon, N. J.
Cross Engineering Co., Carbondale, N. J.
Harrington & King Perforating Co., Chicago.
Webb City and Carterville Fdy. & Mach. Wks., Webb City, Mo.

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ELLICOTT MACHINE CORP., Baltimore, Md. 238
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Austin-Western Road Machy. Co., Chicago.
Greenville Mfg. Co., Greenville, O.
Kritzer Co., Chicago, Ill.
Manganese Steel Forge Co., Philadelphia.
McLanahan-Stone Machine Co., Hollidaysburg, Pa.
Universal Road Machy. Co., Kingston, N. Y.
Webb City and Carterville Fdy. & Mach. Wks., Webb City, Mo.
Western Wheeled Scraper Co., Aurora, Ill.

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Coyle & Roth, Minneapolis, Minn.
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Manganese Steel Forge Co., Philadelphia.
National Engr. Co., Chicago, Ill.
Orville Simpson Co., Cincinnati, O.
Seaverns, James B., Chicago, Ill.
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Webb City and Carterville Fdy. & Mach. Wks., Webb City, Mo.

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National Engr. Co., Chicago, Ill.
Orville Simpson Co., Cincinnati, O.
Seaverns, James B., Chicago, Ill.
Sturtevant Mill Co., Boston, Mass.
Tyler, W. C., Co., Cleveland, O.

SHEAVES

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
HADFIELD-PENFIELD STEEL CO., Bucyrus, O. 207-282
INLAND ENGR. CO., Chicago, Ill. 208
LESCHEN, A., & SONS ROPE CO., St. Louis, Mo. 192-296-297
LINK-BELT CO., Chicago, Ill.......250-251
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Hill Clutch Co., Cleveland, O.
Indiana Foundry Co., Indiana, Pa.
Love Bros. Inc., Aurora, Ill.
McLanahan-Stone Machine Co., Hollidaysburg, Pa.
Roebling's Sons, John A., Co., Trenton, N. J.
Yale & Towne Mfg. Co., Stamford, Conn.

SHOVEL PARTS, MANGANESE STEEL

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
INLAND ENGR. CO., Chicago, Ill.......208
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SHOVELS, POWER, COMPRESSED AIR

Osgood Co., Marion, O.

SHOVELS, POWER, ELECTRIC

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
MARION STEAM SHOVEL CO., Marion, O. 304-305
NORTHWEST ENGR. CO., Chicago 306-307
Austin Machy. Corp., Toledo, O.
Bucyrus Co., South Milwaukee, Wis.
Fairbanks Steam Shovel Co., Marion, O.
Pawling & Harnischfeger Co., Milwaukee, Wis.
Thew Shovel Co., Lorain, O.

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NORTHWEST ENGR. CO., Chicago 306-307
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Fairbanks Steam Shovel Co., Marion, O.
Michigan Dredge Co., Bay City, Mich.
Pawling & Harnischfeger Co., Milwaukee, Wis.
Thew Shovel Co., Lorain, O.

SHOVELS, POWER, STEAM

AMERICAN HOIST & DERRICK CO., St. Paul, Minn. 269
MARION STEAM SHOVEL CO., Marion, O. 304-305
Austin Machy. Corp., Toledo, O.
Bucyrus Co., South Milwaukee, Wis.
Erie Steam Shovel Co., Erie, Pa.
Fairbanks Steam Shovel Co., Marion, O.
Osgood Co., Marion, O.
Thew Shovel Co., Lorain, O.

SPEED REDUCERS

LINK-BELT CO., Chicago, Ill.......250-251
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AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill. 211-231-291
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Harrisburg Mfg. & Boiler Co., New York.
Ryerson, Joseph T., & Son, Chicago, Ill.

STOKERS

Automatic Furnace Co., Dayton, O.
Combustion Engr. Corp., New York, N. Y.
Stroud, E. H., & Co., Chicago, Ill.

TANKS, AIR

NORTHERN BLOWER CO., Cleveland 246
STEACY-SCHMIDT MFG. CO., New York, N. Y. 276
Curtis Pneumatic Machy. Co., St. Louis, Mo.
Heil Co., Milwaukee, Wis.
Heltzel Steel Form & Iron Co., Warren, O.

TANKS, CONCRETE

NEFF & FRY, Camden, O. 200
Concrete Silo Co., Bloomfield, Ind.

TANKS, GASOLINE

NORTHERN BLOWER CO., Cleveland 246
Davis, J. F., & Sons Co., Chicago, Ill.
Heil Co., Milwaukee, Wis.
Standard Steel Works, North Kansas City.

TANKS, IRON

NORTHERN BLOWER CO., Cleveland 246
STEACY-SCHMIDT MFG CO., New York, N. Y. 276
Caldwell, W. E., Co., Louisville, Ky.
Conveyors Corp. of America, Chicago, Ill.
Heltzel Steel Form & Iron Co., Warren, O.
Standard Steel Works, N. Kansas City, Mo.

TANKS, SETTLING

NORTHERN BLOWER CO., Cleveland 246
WEBSTER MFG. CO., Chicago, Ill...252-253
Allen Cone Co., El Paso, Tex.
Standard Steel Works, N. Kansas City, Mo.

TANKS, STEEL

NORTHERN BLOWER CO., Cleveland 246
STEACY-SCHMIDT MFG CO., New York, N. Y. 276
Caldwell, W. E., Co., Louisville, Ky.
Columbian Steel Tank Co., Kansas City, Mo.
Davis, J. F., & Sons Co., Chicago, Ill.
Harrisburg Mfg. & Boiler Co., New York, N. Y.
Heil Co., Milwaukee, Wis.
Heltzel Steel Form & Iron Co., Warren, O.
Littleford Bros., Cincinnati, O.
Merchant Shipbuilding Corp., Chester, Pa.
Murray Iron Works Co., Burlington, Iowa.
Reeves Bros. Co., Alliance, O.
Standard Steel Works, N. Kansas City, Mo.
Walsh & Weidner Boiler Co., Chattanooga.

TANKS, STORAGE

NORTHERN BLOWER CO., Cleveland 246
STEACY-SCHMIDT MFG CO., New York, N. Y. 276
Bland Engr. Co., Minneapolis, Minn.
Caldwell, W. E., Co., Louisville, Ky.
Columbian Steel Tank Co., Kansas City, Mo.
Davis, J. F., & Sons Co., Chicago, Ill.
Heil Co., Milwaukee, Wis.
Heine Boiler Co., St. Louis, Mo.
Heltzel Steel Form & Iron Co., Warren, O.
Merchant Shipbuilding Corp., Chester, Pa.
Standard Steel Works, N. Kansas City, Mo.

TANKS, WATER

NORTHERN BLOWER CO., Cleveland 246
STEACY-SCHMIDT MFG CO., New York, N. Y. 276
Caldwell, W. E., Co., Louisville, Ky.
Heil Co., Milwaukee, Wis.
Heltzel Steel Form & Iron Co., Warren O.
Merchant Shipbuilding Corp., Chester, Pa.
Standard Steel Works, N. Kansas City, Mo.

TANKS, WOOD

Associated Cooperage Industries of America, St. Louis, Mo.
Caldwell, W. E., Co., Louisville, Ky.
Continental Pipe Mfg. Co., Seattle, Wash.

TRACK, FROGS AND SWITCHES

EASTON CAR AND CONSTRUCTION CO., New York, N. Y. 204-205
LAKEWOOD ENGR. CO., Cleveland, O..203
Central Frog & Switch Co., Cincinnati, O.
Weir Frog Co., Cincinnati, O.

TRACTORS

Full Crawler Co., Milwaukee, Wis.

TRAMWAYS, AERIAL

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TRAMWAYS, GRAVITY

LESCHEN, A., & SONS ROPE CO., St. Louis, Mo. 192-296-297

TRAMWAYS, WIRE ROPE

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TRIPPERS, TRAMWAY

WEBSTER MFG. CO., Chicago, Ill...252-253

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Conveyors Corp. of America, Chicago, Ill.

TRUCKS, TRACTOR

LAKEWOOD ENGR. CO., Cleveland, O. 203
Acme Motor Truck Co., Cadillac, Mich.
Baker, R. & L., Co., Cleveland, O.
Electric Wheel Co., Quincy, Ill.
General Motors Truck Co., Pontiac, Mich.
Yale & Towne Mfg. Co., Stamford, Conn.

TRUCK TRAILERS

Highway Trailer Co., Edgerton, Wis.
Lee Trailer & Body Co., Chicago, Ill.
Mansfield Steel Corp., Detroit, Mich.

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ALBANY grease—Adam Cook's Sons, Inc., New York, N. Y.
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ALLIGATOR wrenches—John A. Roebling's Sons Co., Trenton, N. J.
AMERICAN cranes, hoists, derricks, etc.—American Hoist & Derrick Co., St. Paul, Minn.
AMERICAN high speed chains—American High Speed Chain Co., Indianapolis, Ind.
AMERICAN pumps, blast hole drills—American Well Works, Aurora, Ill.
AMERICAN pulverizer—American Pulverizer Co., St. Louis, Mo.
AMERICAN-MARSH pumps, agitators, etc.—American Steam Pump Co., Battle Creek, Mich.
AMMITE dynamite—Atlas Powder Co., Wilmington, Del.
AMPERE belting—Victor Balata & Textile Belting Co., New York, N. Y.
AMSCO manganese steel castings—American Manganese Steel Co., Chicago Heights, Ill.
ANDERSON oil engines—Anderson Foundry & Machine Co., Anderson, Ind.
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ASBESTALL friction blocks—J. S. Mundy Hoisting Engine Co., Newark, N. J.
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ATLAS cars, locomotives—Atlas Car & Mfg. Co., Clevelanad, Ohio.
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BRADLEY 3 ROLL mill—Bradley Pulverizer Co., Allentown, Pa.
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BRISTOL'S temperature controller—Bristol Co., Waterbury, Conn.
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DUPONT explosives—E. I. du Pont de Nemours & Co., Wilmington, Del.
DUROX explosives—E. I. du Pont de Nemours & Co., Wilmington, Del.
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ERA manganese steel—Hadfield-Penfield Steel Co., Bucyrus, O.
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ERIE pumps, engines—Erie Pump & Engine Works, Medina, N. Y.
ERIE steam shovels—Erie Steam Shovel Co., Erie, Pa.
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HEART transmission belting—Graton & Knight Mfg. Co., Worcester, Mass.
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HERCULES explosives, blasting supplies—Hercules Powder Co., Wilmington, Del.
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HY-SPEED tripod drills—Sullivan Mach'y Co., Chicago, Ill.
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Co., Bay City, Mich.
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LITTLE GIANT portable pneumatic grinders—Chicago Pneumatic Tool Co., New York, N. Y.
LITTLE GIANT electric drills—Chicago Pneumatic Tool Co., New York, N. Y.
LITTLE GIANT pneumatic hoists—Chicago Pneumatic Tool Co., New York, N. Y.
LITTLE GIANT portable air drills—Chicago Pneumatic Tool Co., New York, N. Y.
LITTLE GIANT portable electric grinders—Chicago Pneumatic Tool Co., New York, N. Y.
LITTLE GIANT portable pneumatic grinders—Chicago Pneumatic Tool Co., New York, N. Y.
LITTLE GIANT portable hoists—Ingersoll-Rand Co., New York, N. Y.
LOBDELL car, locomotive wheels, axles, brake linings—Lobdell Car Wheel Co., Wilmington, Del.
M-S-A first aid supplies—Mine Safety Appliances Co., Pittsburgh, Pa.
MAMMOTH crusher—Williams Pat. Crusher & Pulv. Co., St. Louis, Mo.
MANCHA'S ELECTRIC MULE locomotive—Mancha Storage Battery Locomotive Co. St. Louis, Mo.
MARION steam shovels—Marion Steam Shovel Co., Marion, O.
MATCHLESS trolleys—Chisholm-Moore Mfg. Co., Cleveland, O.
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MILBURN lights—Alexander Milburn Co., Baltimore, Md.
MILBURN welding equipment—Alexander Milburn Co., Baltimore, Md.
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MINISTER gasoline locomotives—Industrial Equipment Co., Minster, O.
MISSOURI SAVAGE fire brick—Chicago Fire Brick Co., Chicago Ill.
MONIGHAN dragline boom—Monigh n Machine Co., Chicago, Ill.
MORRIS engines—Morris Machine Works, Baldwinsville, N. Y.
MORRIS pumps—Morris Machine Works, Baldwinsville, N. Y.
MOUNT VERNON belting—Mount Vernon Belting Co., Baltimore, Md.
MUNDY hoists—J. S. Mundy Hoisting Engine Co., Newark, N. J.
Munson mills, crushing, grinding—Munson Mill Mach'y Co. Inc., Utica, N. Y.
MURRAY boilers—Murray Iron Works Co., Burlington Iowa.
NATIONAL hoisting engines—National Hoisting Engine Co., Harrison, N. J.
NEPTUNE transmission belting—Graton & Knight Mfg. Co., Worcester, Mass.
NEPTUNE DYNAMO transmission belting—Graton & Knight Mfg. Co., Worcester, Mass.
NEW HOLLAND crushers—New Holland Machine Co., New Holland, Pa.
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NINETIES drills—Denver Rock Drill Mfg. Co., Denver, Colo.
NIP pipe fittings—Kelly & Jones Co., Greensburg, Pa.
NORBLO air separators—Northern Blower Co., Cleveland, O.
NORTWEST CRAWLER crane, dragline, power shovel—Northwest Engr. Co.,, Chicago, Ill.
NORUSTOCTA pipe fittings—Kelly & Jones Co., Greensburg, Pa.
NOVAL nickel anti-friction metal—Union Smelting and Refining Co. Inc., Newark, N. J.
NOVO gasoline engines—Novo Engine Co., Lansing, Mich.
OBSTITCH belting—Mount Vernon Belting Co., Baltimore, Md.
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OLD COLONY hose, belting—Geo. B. Carpenter & Co., Chicago, Ill.
OLYMPIC wire rope—Hazard Mfg. Co., Wilkes-Barre, Pa.
OSGOOD power shovel—Osgood Co., Marion, O.
OWEN clamshell buckets—Owen Bucket Co., Cleveland, O.
OXWELD acetylene welding equipment—Oxweld Acetylene Co., Newark, N. J.
P. P. P. rod packing—Quaker City Rubber Co., Philadelphia, Pa.
PEERLESS chain—Jeffrey Mfg. Co., Columbus, O.
PENN pipe fittings—Kelly & Jones Co., Greensburg, Pa.
PENNSYLVANIA crushers — Pennsylvania Crusher Co., Philadelphia, Pa.
PETROL belting—Victor Balata & Textile Belting Co., New York, N. Y.
PINTITE couplings—Smith & Serrell, Newark, N. J.
PLYMOUTH gasoline locomotives—Fate-Root-Heath Co., Plymouth, O.
PNEUMELECTRIC drills — Pneumelectric Corp., Syracuse, N. Y.
POW-R-FULL POLYPHASE motor—Wagner Electric Corp., St. Louis, Mo.
PRIMM oil engines—Power Mfg. Co., Marion, O.
PULVERBURNERS pulverized fuel equipment—K-B Pulverizer Corp., New York, N. Y.
QUAKER CITY belting—Quaker City Rubber Co., Philadephia, Pa.
RADIAL portable loader—Jeffrey Mfg. Co., Columbus, O.
READING car replacers—American Chain Co., Inc., Bridgeport, Conn.
RECORD anti-friction metal—Union Smelting & Refining Co., Newark, N. J.
RED CROSS EXTRA explosives—E. I. du Pont de Nemours & Co., Wilmington, Del.
RED-STRAND wire rope—A. Leschen & Sons Rope Co., St. Louis, Mo.
RELIANCE air separators, bucket elevators, crushers, screens—Universal Road Mach'y Co., Kingston, N. Y.
RELIANCE chain—Jeffrey Mfg. Co., Columbus, O.
RELIANCE electric motors, generators—Reliance Electric & Engr. Co., Cleveland, O.
REPUBLIC hose—Republic Rubber Co., Youngstown, O.
REPUBLIC motor trucks—Republic Truck Sales Corp., Alma, Mich.
REXALL conveyor belting—Imperial Belting Co., Chicago, Ill.
ROTATOR hammer drills—Sullivan Mach'y Co., Chicago, Ill.
ROYAL WORCESTER transmission belting—Graton & Knight Mfg. Co., Worcester, Mass.
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